FINAL REPORT OF THE REGIONAL ENERGY DEMAND PLANNING PROJECT

FUTURE ENERGY SCENARIOS IN SOUTHEAST EUROPE AND THE POTENTIAL FOR ENERGY EFFICIENCY – REGIONAL AND INDIVIDUAL COUNTRY RESULTS FOR BULGARIA

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FUTURE ENERGY SCENARIOS IN SOUTHEAST EUROPE AND THE POTENTIAL FOR ENERGY EFFICIENCY

HIGHLIGHTS OF THE REGIONAL ANALYSIS WITH DETAILED BULGARIA RESULTS

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EXECUTIVE SUMMARY

CONTEXT

The countries of South East Europe are developing regional approaches to energy cooperation. The Athens Treaty that came into force in July 2006 encourages creating regional electricity and gas markets as steps towards integration into the European Union's (EU's) Internal Energy Market. Countries in the region are in varying stages of transition to competitive markets and accession to the European Union. There are several core issues that should be examined as countries transition to liberalized energy markets while simultaneously addressing EU directives and fostering development of globally competitive economies. These issues include: the relationship between economic growth and energy demand, the potential for energy efficiency gains, the increased role for natural gas and renewables, and full integration and harmonization of the regional electricity and natural gas systems.

As is detailed in Section 2, the Reference scenario, continuation of current trends in regional energy use, shows aggregate energy use for the region increasing by almost 60 percent [and electricity use rising by over 80 percent] over the next 27 years. Careful planning and the institution of policies to foster more efficient and cost-effective energy technologies could temper this growth, while providing significant environmental and economic benefits. The goal is to lay the foundation for fostering a better understanding of the possible paths for the evolution of the national energy systems by building analytical capacity within the region to inform energy planners and decision-makers and to use these tools to examine the costs and benefits of more efficient alternatives to the current course of energy policy.

This report summarizes the results to date of the United States Agency for International Development (USAID)-supported Regional Energy Demand Planning (REDP) activities under the South East Europe Regional Energy Market Support (SEE REMS) Project (10/1/2004 – 9/30/2008). The original countries directly involved in implementing the planning activities included Albania, Bulgaria, Bosnia and Herzegovina, Croatia, Macedonia, Romania, Serbia and Montenegro and the United Nations Interim Mission in Kosovo (UNMIK pursuant to the UN SCR 1244). Under REDP, USAID sought to complement the work begun under the Generation Investment Study (GIS) [1] of the World Bank by conducting a more detailed analysis of the demand for energy and the competing factors and policies that will shape this demand.

ACCOMPLISHMENTS

The SEE REMS project supported teams from the energy planning ministries of each country in developing National Energy Planning Models using the MARKAL/TIMES framework[2]. These national models provide a framework for exploring policy options and investment strategies, integrating supply-side and demand-side options to promote the cost-effective evolution of the energy systems in each country, and in the region as a whole.

For each country model, the current energy system was depicted and calibrated using 2003 national energy balance data to produce a baseline "snapshot" of the technology stock in place. Forecasts for economic growth were translated into projected future demands for energy services (e.g., heating buildings, lighting houses, providing high-temperature heat to industry) out to 2027. The technical and economic characterizations of existing and advanced energy supply and end-use technologies were incorporated into the models, and each of the country teams used its knowledge and expert judgment to refine the models'

1 Development of Power Generation In the South East Europe Update of Generation Investment Study, , Volume 1: Summary Report, Final Report, prepared by South East Europe Consultants Ltd. for The World Bank, January 9, 2007.

2 A widely applied full-sector energy systems modeling platform that can analyze energy, economic and environmental issues at the global, national and municipal levels, over several decades; www.etsap.org.

projection of a Reference (or continued current dynamics) scenario for each country. This scenario then served as the comparison point for evaluating the benefits, costs, and technology investments that would result from the implementation of possible future government policies, programs, environmental constraints, and various resource supply options.

As part of this USAID project the regional capacity to perform national energy system modeling and analysis has been created by mentoring the country teams through the process of model development and utilization. As this report demonstrates, the teams now have the capacity to perform meaningful analyses with their models. This capacity is a significant first step towards better informed national and regional policy making decisions based on more robust, locally guided, analyses – the ultimate objective of the REDP. With this foundation, policy makers in the region can now collaborate with the country model teams to perform ever changing analyses of various economic and policy scenarios to evaluate the costs and benefits of a range of mechanisms and select the preferred set of actions to effect desired outcomes. The potential benefits are enormous – in terms of more efficient investment, enhanced energy security, increased environmental protection, and more targeted policies with fewer unanticipated impacts.

The analysis in this report focuses largely on potential benefits to be gained from efficiency improvements and examines both supply-side solutions and introduction of programs and policies to encourage investments in demand-side energy efficiency measures and thereby reduce necessary supply-side costs. The indicative policy analyses indicate the resultant benefits in terms of energy security (less imports) and competitiveness (better energy intensity at acceptable cost).

ANALYTICAL RESULTS

This report presents the results of a few indicative policy scenario analyses performed using the newly built models and provides insights into regional and national energy system dynamics by:

- Quantifying the energy supply needed to meet future energy demand;
- Comparing the investments (supply-side and end-use) and fuel expenditures required to implement alternate policies relative to the Reference scenario;
- Identifying the impacts of those policies on technology choices and fuel mix in the different demand sectors; and
- Examining the changes in energy system costs, energy security and environmental impacts.

The analysis explores the potential role of policies aimed at encouraging greater energy efficiency throughout the region using three alternatives to the Reference scenario representing progressively stronger implementation of energy efficiency measures:

- ***Promoting Energy Efficiency (R90)*** – accelerated adoption of more energy efficient end-use devices
- ***Reducing Electricity Consumption (R90E)*** – a "mandated" 10% reduction in electricity consumption from the Reference levels and
- ***Reducing Energy Intensity (R90P) –*** a cost-effective (relative to the Reference scenario) reduction in overall energy system intensity achieved by limiting total energy use (supply and end-use).

The primary results of the analysis are summarized in Table ES-1, and Figures ES-1 and ES-2. Table ES-1 shows the range of cost and energy savings provided by the three scenarios relative to the Reference scenario.

Table ES-1. Benefits Arising from Increased Energy Efficiency

Improvement	Benefit Range (in 2027)
Total discounted energy system cost savings	1.5 - 2% (€3.78 - €6.06 billion) over the planning horizon
Change in undiscounted annual costs	
Power plant investment	Decrease of .2 – 15% (5 - 455€ million)
Demand-side investment	Increase of 14 – 28% (1.59 – 3.16€ billion)
Fuel Expenditure	Decrease of 13 – 16% (€3.43/3.36/4.04 billion)
Annual energy savings	9 – 18% (417 – 793 PJ)
Annual electricity savings	6 – 11% (17 - 33GWh)
Reduction of imports	16 – 17% (309 – 343 PJ)
Decrease in energy intensity	9.4 – 18%

Figure ES-1 shows the decrease in regional energy intensity in 2027 achieved through implementation of the energy efficiency policies described above compared to the Reference case. At the same time, the alternate scenarios lower the total energy system cost (including investments in new capacity and demand devices, expenditure on fuel, transmission and distribution infrastructure, etc., to the extent represented in the models) by almost 2% for the Promoting Energy Efficiency scenario (R90) and by 1.2% for the Reducing Electricity Consumption (R90E) scenario. For the Reducing Energy Intensity (R90P) scenario, the total energy system cost approximates that of the Reference scenario, indicating the level of improvement that can be achieved at costs similar to those of the Reference scenario. Figure ES-2 shows that the overall cost of implementing the energy system improvements represented in these alternate scenarios is relatively small because the increased investments made in more efficient end-use technologies are offset by significant reductions in fuel expenditures and modest reductions in the level of new investments in the power sector. Further details of the assumptions, costs, and benefits of these scenarios are provided in subsequent sections of this report.

Figure ES-1: Aggregate Reduction in Regional Energy Intensity in 2027 Relative to the Reference Case

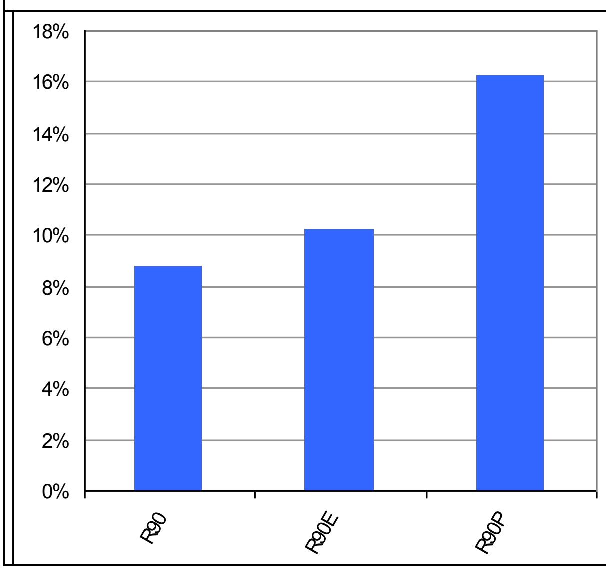
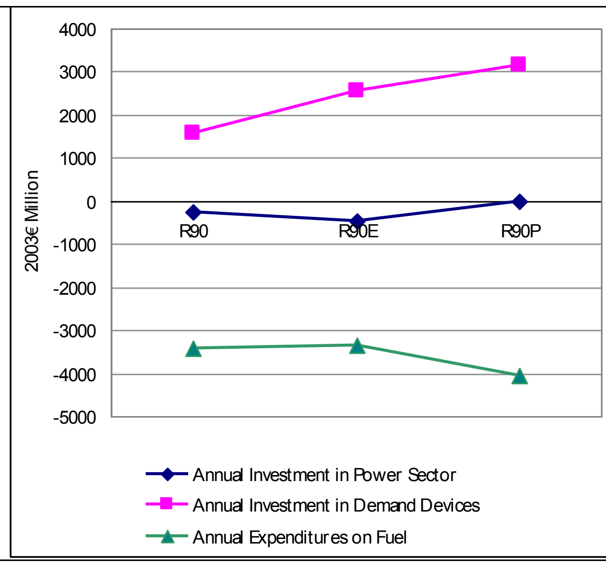


Figure ES-2: Change in 2027 Annual Expenditures



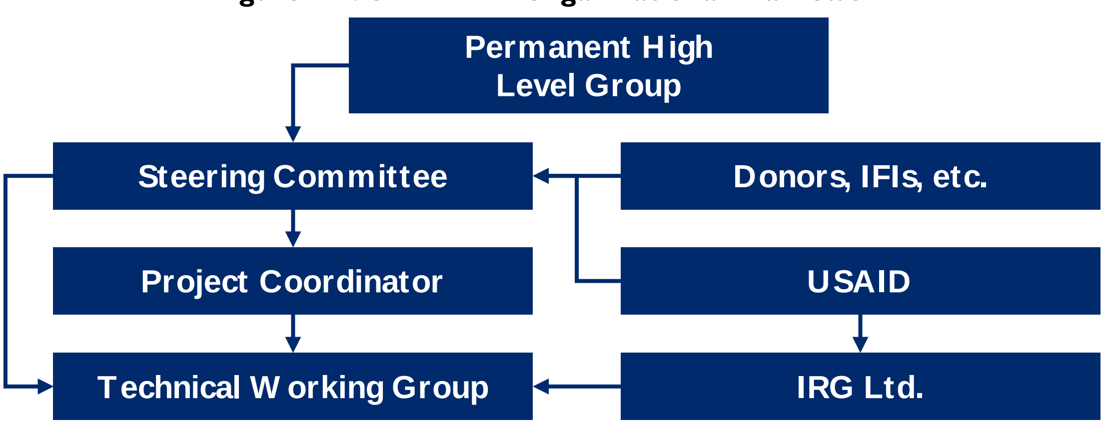
HIGHLIGHTS OF THE REGIONAL ANALYSIS

1.1 PROJECT OVERVIEW

Background. This report summarizes the results of the USAID-supported Regional Energy Demand Planning (REDP) activities under the South East Europe Regional Energy Market Support (SEE REMS) Project (10/1/2004 – 9/30/2008). The REDP activities were initiated as one component of the multi-faceted SEE REMS project to accelerate regional energy development and cooperation in South East Europe. The Athens Memoranda of Understanding of November 2002 and December 2003 provided the basis for the countries' collaborative efforts to create integrated regional electricity and gas markets for eventual incorporation into the EU Internal Energy Market. This effort culminated in the signing of the Treaty to establish the Energy Community (signatories included the EU, Albania, Bulgaria, Bosnia and Herzegovina, Croatia, the former Yugoslav Republic of Macedonia, Romania, Serbia and Montenegro and the United Nations Interim Mission in Kosovo (UNMIK). Under REDP, USAID extended the work begun under the Generation Investment Study (GIS) of the World Bank, by conducting more detailed demand analysis and forecasting. The goals of this undertaking were to forge a better understanding of the possible paths for the evolution of the individual countries' energy systems by building analytical capacity within the region to better inform decision-making.

Approach. A Steering Committee (SC) of national policy makers was established by the Permanent High Level Group (PHLG) to guide and oversee the activities of the REDP. The Steering Committee, in turn, nominated representatives for the Technical Working Group (TWG) from 8 countries tasked to identify and collect the data necessary to depict the current energy system in each country. The project organizational structure and the key local institutions comprising the SC and TWG are presented in Figure 1-1 and Table 1-1. Under the direction of a team of international modeling experts from International Resources Group (IRG), the TWG members have incorporated their national energy system information into a robust energy planning framework for each country built upon the MARKAL/TIMES[3] modeling platform.

Figure 1-1: SEE-REDP Organizational Framework



[3] MARKAL/TIMES is a modeling framework developed under the auspice of the International Energy Agency's Energy Technology Systems Analysis Programme (IEA-ETSAP, www.etsap.org) and widely used around the world for integrated energy system planning.

Table 1-1: SEE-REDP Participating Institutions

Country	Steering Committee	Technical Working Group
Albania	National Agency of Natural Resources	National Agency of Natural Resources
Bosnia	Ministry of Foreign Trade and Economic Relations	Ministry of Foreign Trade and Economic Relations Federal Ministry of Energy
Bulgaria	Ministry of Economy and Energy	Ministry of Economy and Energy
Croatia	Ministry of Economy, Labor and Entrepreneurship	Ministry of Economy, Labor and Entrepreneurship
Macedonia	Electric Power Company of Macedonia	Electric Power Company of Macedonia
Montenegro	Ministry of Economy	Ministry of Economy
Romania	National Power Grid Company – Transelectrica	National Power Grid Company – Transelectrica
Serbia	Ministry of Energy and Mining	Electric Power Industry of Serbia
UNMIK	Ministry of Energy and Mining	Ministry of Energy and Mining Energy Regulatory Office

The Steering Committee, in consultation with USAID, identified a number of interesting energy policy issues for examination utilizing the national models.

- The potential role of energy efficiency and conservation in curbing growth in energy demand
- Diversification and security of energy supply
- The role of renewables in diversifying energy supply
- Impacts of increased utilization of nuclear power
- Optimal use of increased availability of natural gas
- The pathway necessary to attain various EU energy and environmental targets
- The effect of eliminating energy price subsidies
- Evaluation of requirements to support more rapid economic growth, and
- The potential benefits of regional electricity and gas markets

Once the national models were in place, the TWG conducted an initial analysis of the potential role of energy efficiency in curbing growth in energy demand. Development of these scenarios and the ensuing analysis has established the foundation for investigating other issues of national and regional importance as they arise. This report documents those activities and the results obtained. Several of the Appendices document analysis of country-specific issues taken on by the TWG.

Development of the National Energy Planning Models. The MARKAL/TIMES model is a flexible and comprehensive energy systems analysis platform that can analyze energy, economic and environmental issues at the global, national and municipal levels, over several decades. It provides a framework for exploring policy options and investment strategies that shape the evolution of an energy system, and for evaluating and analyzing the implications of alternative policy and investment choices. It is widely used in over 60 counties by more than 200 government, research and university institutions.

The MARKAL/TIMES model can evaluate the costs and benefits incurred in the process of achieving various goals. The model does not forecast, but rather examines "what if" scenarios, highlighting the differences and requirements of each of the alternative development paths. The model's strength is its technology richness, transparent architecture (with respect to both data and well-understood methodology), and usability owing to robust analyst support systems. It is a full-sector model, meaning that it encompasses not just power generation but also resource supply options, upstream fuel production and all forms of energy consumption in all demand sectors of an economy. The model accepts agriculture, commercial, industrial, residential, and transportation demands for energy services for the next several decades, and determines where the sources of energy will originate (whether domestic or imported), which technologies transform primary energy into final energy (e.g., power plants), and what end-use devices will then meet the demands for energy services. The components are tied together by means of a Reference Energy System (RES) which establishes the network of energy flows and technology options encompassing the area of study. The characteristics of each technology (resource supply, process, conversion and end-use) include the investment cost, operating and maintenance costs, service life, efficiency, availability and emissions.

For each of the SEE-REDP countries, the current energy system was depicted and economic forecasts were translated into future demands for energy services (e.g., heating buildings, lighting houses, providing high-temperature heat to industry). The TWG, mentored by IRG modeling experts provided by USAID, developed technical and economic characterizations of advanced supply and end-use technologies and incorporated these characterizations into the models. Each of the TWG members then refined the key assumptions based on their knowledge and expert judgment of the future energy system. Collectively, these inputs form the basis of the Reference scenario for each country. This scenario then serves as the reference point for investigating the evolution of the energy system under alternative conditions resulting from changes in government policy, environmental constraints, or various resource supply options.

Capacity Building. A primary objective of this USAID project has been the development of regional capacity to perform national energy system modeling and analysis. Therefore a large part of the effort over the initial two years was dedicated to mentoring the TWG through model development and utilization. The TWG's capacity is demonstrated by their achievement of the following milestones:

- Establishment of a 2003 energy balance, adapted to the model needs;
- Decomposition of the initial energy balance to determine the appropriate depiction of resources (including imports), conversion technologies, end-use devices and energy service demands, which formed the underlying Reference Energy System (RES) for each country;
- Calibration of the models' results for the base year (2003), including depiction of the capacity and performance of existing assets;
- Development of the 2003 to 2027 Reference scenario, and
- Preparation and analysis of alternate scenarios.

Over the course of this 30-month effort, the TWG members have not only achieved these milestones but also demonstrated their individual and collective capacity to perform meaningful analyses with their models. The TWG's capacity to utilize the national models to run and interpret the results of various future scenarios constitutes a strong first step towards better informed national policy making based on robust analyses – the ultimate objective of the REDP.

Report Objectives. The objective of this report - *The Analysis of Future Energy Demand Trends – A Clear Case for Energy Efficiency in the South East Europe Regional Energy Market* - is to demonstrate the new planning capabilities established in the region by presenting the results of a few indicative policy scenario analyses performed by the TWG. The report examines scenarios for a range of energy efficiency possibilities for regional and national energy system dynamics by:

- Quantifying the future demand for energy to meet basic energy services;
- Illustrating the investments required to implement various policies;

- Identifying the impacts of those policies on technology choices and fuel mix; and
- Examining the benefits relative to energy system costs and energy security.

This report demonstrates the growing skills of the country experts in working with their models. This section summarizes the aggregate Reference case results from the 8 national models, and presents highlights of the indicative Policy scenario results.

Indicative Policy Analyses. The following three policy scenarios were selected for presentation because they best demonstrate how the country energy systems might respond to a set of efficiency-promoting policies or programs. The selected policy scenarios were designed to model increasingly stringent efficiency targets as well as alternative economic mechanisms to provide insight in the costs and benefits of each approach.

- ***Promoting Energy Efficiency -*** accelerating the adoption of more energy efficient end-use devices through better consumer information, improved standards, market incentives, and other similar approaches.
- ***Reducing Electricity Consumption*** – achieving a 10% reduction in electricity consumption below Reference case levels by establishing regional, sectoral or other electricity use targets and implementing market-based mechanisms to facilitate meeting the targets.
- ***Reducing Energy Intensity***[4] **–** achieving overall energy system intensity improvements within the same lifetime energy system cost as in the Reference case, most likely through a combination of the above measures.

The types of policies and programs that can achieve these goals (e.g., efficiency standards for appliances, information campaigns) are examined and evaluated in terms of the impacts on energy security, electricity generation and investment requirements and consumption patterns.

The current models are not complete since the transport sector characterization includes only electricity demand, thus understating the overall level of energy demand – particularly oil. That is not a concern for this analysis since the focus is on energy efficiency in buildings and industry. A more complete representation of the transport sector would provide a fuller picture of the region's future energy system and could be readily added.

In addition, under the current framework each country is modeled separately. Therefore, the models have no internal framework to depict trade of electricity, natural gas and other energy sources. As a result, the regional results are an aggregation of the individual country results, rather than a full regionalized perspective. The lack of a regionally integrated model also prevents full analysis of supply diversification options or electricity trade at this time. Thus these results will tend to be more costly than might otherwise be the case if cooperative regional approaches were taken as common challenges. However, the foundation is laid and the models could be integrated into a comprehensive regional framework with modest additional effort.

1.2 REFERENCE SCENARIO HIGHLIGHTS

The Reference scenario describes how the energy systems will evolve absent any major changes in system direction [e.g., energy efficiency improvements, energy diversity]. A full description of the data development, model calibration and Reference scenario development process as well as a fuller description of the regional Reference scenario results are provided in Section 2.

[4] Energy intensity being measured by (total primary energy consumption / GDP) and thus reflecting the amount of energy needed to drive the economy.

The Reference scenario serves as the comparison point for the analysis of scenarios designed to model specific policies, programs and future energy system options. Each country Reference scenario has been established by:

- developing demand service drivers (e.g., GDP, population) and associating them with each of the sectors to establish an initial projection of future useful energy services (e.g., space conditioning, cooking);
- adopting forecasts of energy supply prices from the EU New Energy Externalities Development for Sustainability (NEEDS)[5] project trends, adapted for each country by its TWG representative;
- establishing an appropriate set of future power, coupled heat and power, and heating plants (centralized and decentralized) as well as demand devices based upon IEA/ETSAP technology characterizations, adapted to the SEE situation, and
- establishing mechanisms for "guiding" model choices in situations where there are limitations on system evolution that inhibit the selection of ideal economic choices.

Future Energy Service Demands. In the MARKAL/TIMES modeling framework, a distinction is made between the demand for energy services (or useful energy) and the end-use consumption of energy (or final energy). The demands for useful energy services (e.g., petajoules of heating and cooling, lumens of light, etc.) is the key input driving the models, which then calculate the resulting consumption of final energy (electricity, gas, coal, etc), and the host of resources and technologies that are utilized to deliver that energy as primary outputs of the model.

The starting point for developing the national projections for future energy service demands is establishing the useful energy demand in the base year. This is done by decomposition of the national energy balances, apportioning the initial year final energy consumption to the various end uses and using the performance characteristics of the existing technology stock to compute the useful energy provided. Once the initial year's useful energy demand is established, sector appropriate drivers and elasticities are applied to shape the evolution of the demand for energy services in response to the projected economic and demographic circumstances.

The main drivers used in the SEE-REDP MARKAL model are:

- GDP and GDP per capita growth;
- population and number of household growth; and
- industrial production growth, with a distinction between energy intensive sectors (ferrous and non ferrous metals, chemicals, and other energy–intensive industries), and other industries and services, where available.

Fuel Price and Availability. Another key input to the models is the cost and availability of the domestic and imported energy resources available to the energy system. For the imported fuels, world energy price projections are used to compute their price evolution (see Figure 2-2). For domestic mined or extracted resources, price trends were established that track the imported fuel prices, except where local conditions dictate otherwise (e.g., cheaper mined coal). Fuel price trajectories were taken from the EU NEEDS project and adapted for the SEE situation. The price trajectories are based upon $60/barrel oil, which could be considered conservative today, and will understate the benefits of energy efficiency.

Limits on the availability of domestic resources is either a function of current extraction capability and proven reserves (e.g., for coal mining) or estimated potential (e.g., for hydro, wind, solar, biomass). For imported

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5 http://www.needs-project.org/rs2a.asp.

fuels, the availability limits are based upon country specific infrastructure limits for transport and delivery of each fuel.

Technology Characterizations. During model calibration, the stock and base year operation of the existing power plants (electric, coupled heat and power, heating) and end-use demand devices (furnaces, air conditioners, industrial process heat, lighting, etc.) was established within the models.

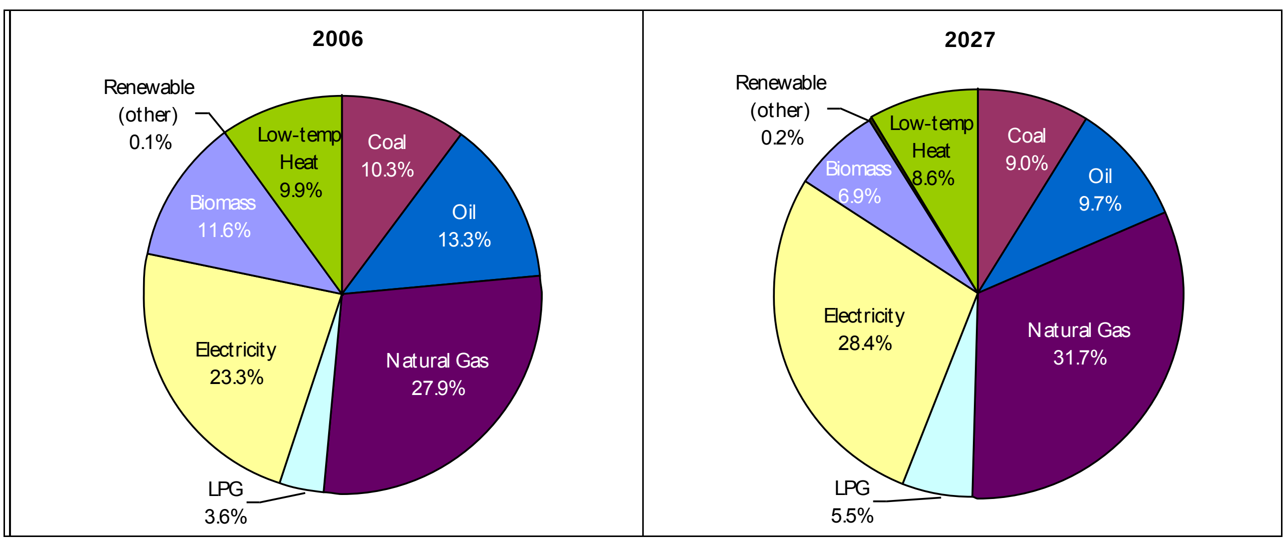
A suite of future technology options for both power plants and demand devices was derived from the Eastern Europe module of the IEA Energy Technology Perspective (ETP) model, the EU-NEEDS database, and other European MARKAL models and made available to each country model. The set of options was cross-checked against the published GIS information, and where needed the characterizations were adjusted to bring them in-line with what was used for the GIS.

Each TWG member then selected from this suite an appropriate set of new technologies for inclusion into their models. For each type of demand device, a variety of new devices with incrementally improved efficiency and higher cost where chosen.

Model Constraints. A MARKAL model is driven by its least-cost paradigm, which can sometimes lead to rates of change that are not reasonable within a real energy system. Therefore, limits on the rate and degree to which fuel switching may occur have been incorporated into the country models. In addition, there is a different set of constraints that limits the rate and degree to which the models can introduce new technology options. These constraint mechanisms are adjustable and can be relaxed or tightened as needed to model a particular alternate scenario. In the Reference scenario the penetration of advanced technologies (available from 2009 or after) was limited to 5-10% depending on the country.

Final Energy Consumption. The aggregate Reference scenario energy consumption grows by 57% during the course of the planning horizon. Figure 1-2 shows how the composition of fuel types changes, with electricity and natural gas increasing the most; and coal, oil and biomass decreasing the most.

Figure 1-2: Aggregate Final Energy Consumption by Fuel Type for the Region[6]



As shown in Figure 1-3, the greatest increase in end-use energy consumption will occur in the industrial and commercial sectors, with the residential sector consumption shrinking in percentage terms.

6 "for the Region" means for all 8 of the SEE countries participating in the project.

Figure 1-3: Aggregate Final Energy Consumption by Sector for the Region

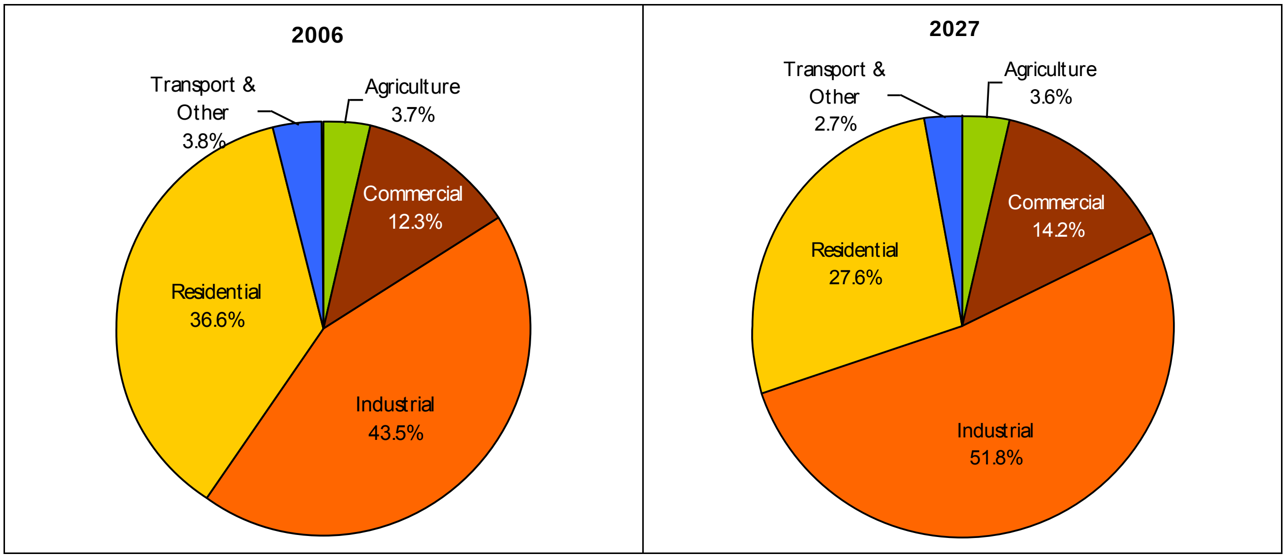
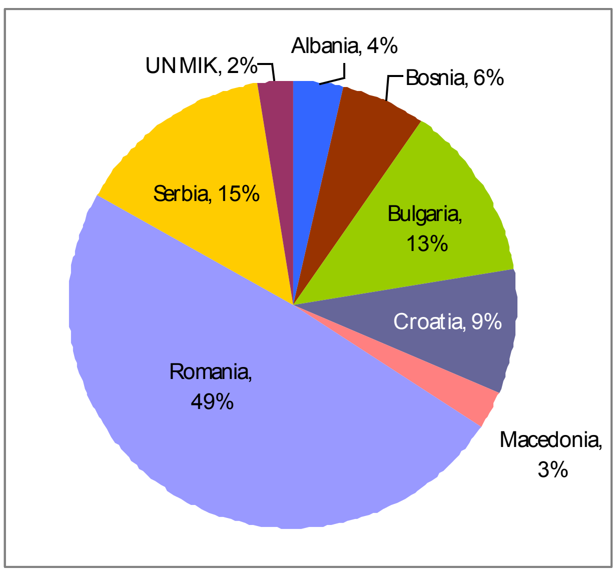


Figure 1-4 shows the share of final energy consumption by country over the full 27-year planning horizon. Romania requires nearly half of all the energy consumed, followed by Serbia, Bulgaria and Croatia.

Figure 1-4: Share of Cumulative Final Energy Consumption by Country



Electricity Generation. In aggregate, electricity generation in the Reference scenario increases from 157 GWh in 2006 to 288 GWh by 2027, an 84% increase. This is consistent with the results of the World Bank Generation Investment Study (GIS), which projected 180-275GWh of electricity generation in 2027, depending upon the scenario. In the current individual country models, imports and exports are capped at 2003 levels, and the benefits of greater regional integration cannot be assessed until the models are linked.

Figure 1-5 shows the following changes in electricity generation by 2027:

- Coal/lignite remains the dominant fuel, providing 42% of total generation
- Nuclear has the biggest increase, moving up to 20.6% of total generation

- Hydro and gas-fired plants drop to 21.9% and 6.7% respectively, and
- Renewables and other plants move from nearly 0% to 5%, comprised of biomass, combined heat and power and wind.

Figure 1-6 shows the country contribution to electricity generation over the model planning horizon. Romania, Serbia and Bulgaria remain the three largest contributors. Several countries show growth rates of over 90%, including UNMIK (+300%), Serbia, Bosnia & Herzegovina, Albania, and Romania.

Figure 1-5: Aggregate Electricity Generation by Fuel Type for the Region

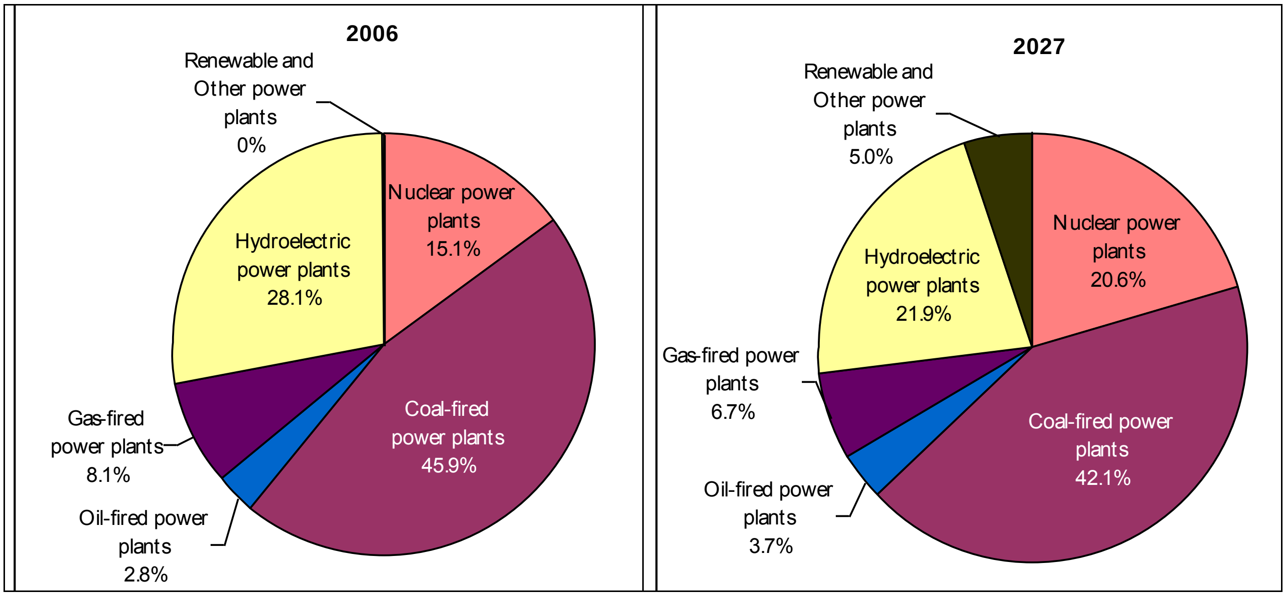
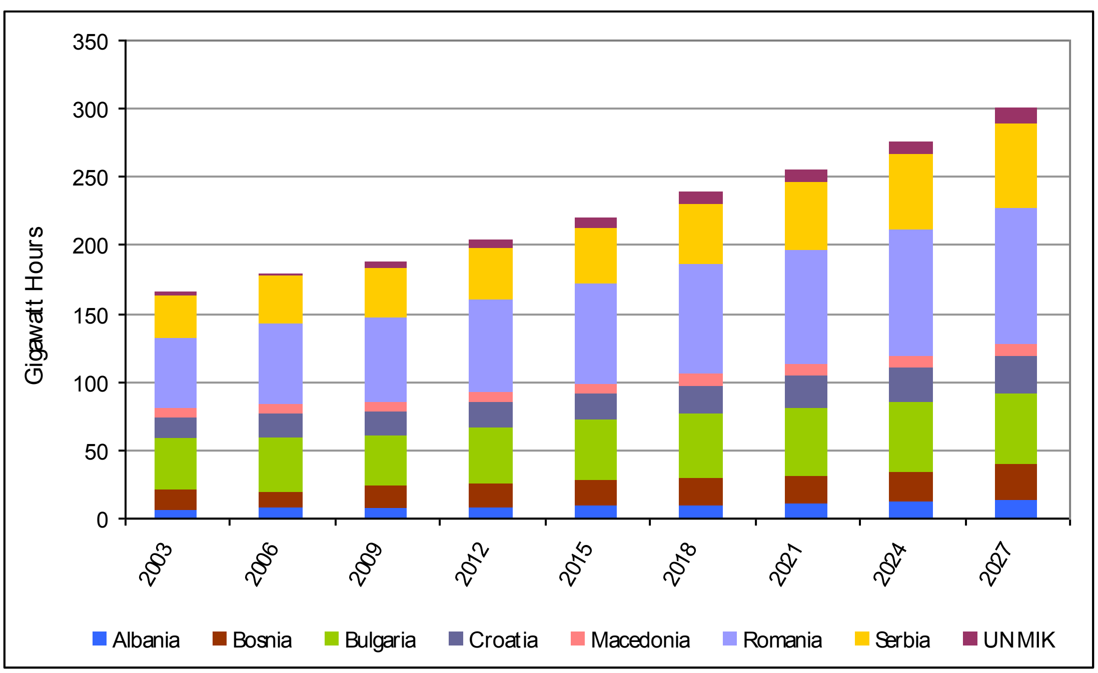


Figure 1-6: Electricity Generation for the Region



Primary Energy Supply. The total domestic and imported energy required to meet the demand for energy services in the Reference scenario increases by 39% in 2027 over the entire region. Figure 1-7 shows the composition of primary energy use in the Reference scenario, which indicates that:

- Nuclear energy's contribution increases the most, from 8.9% to 14%;
- The roles of coal, oil, and biomass drop modestly; and
- Natural gas use holds fairly steady, with a slight increase in LPG use.

Figure 1-8 shows the base-year (2003) primary energy composition in the eight countries and illustrates the diversity of the energy systems in the region.

Figure 1-7: Aggregate Primary Energy Use for the Region

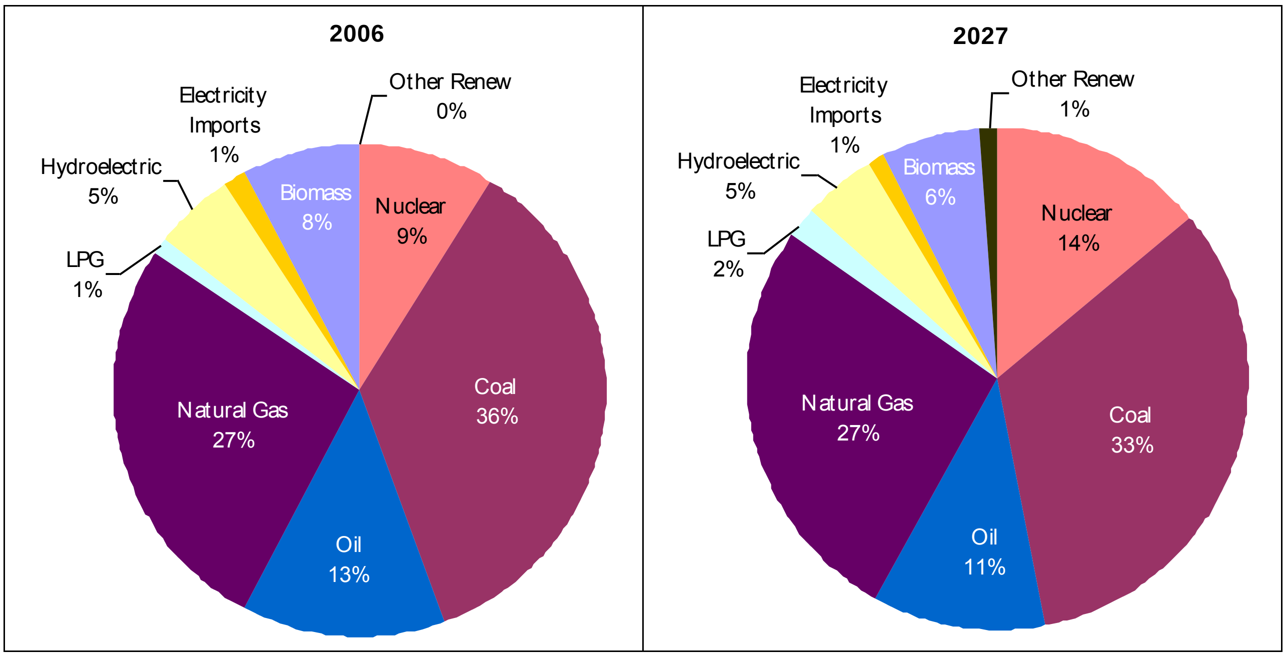
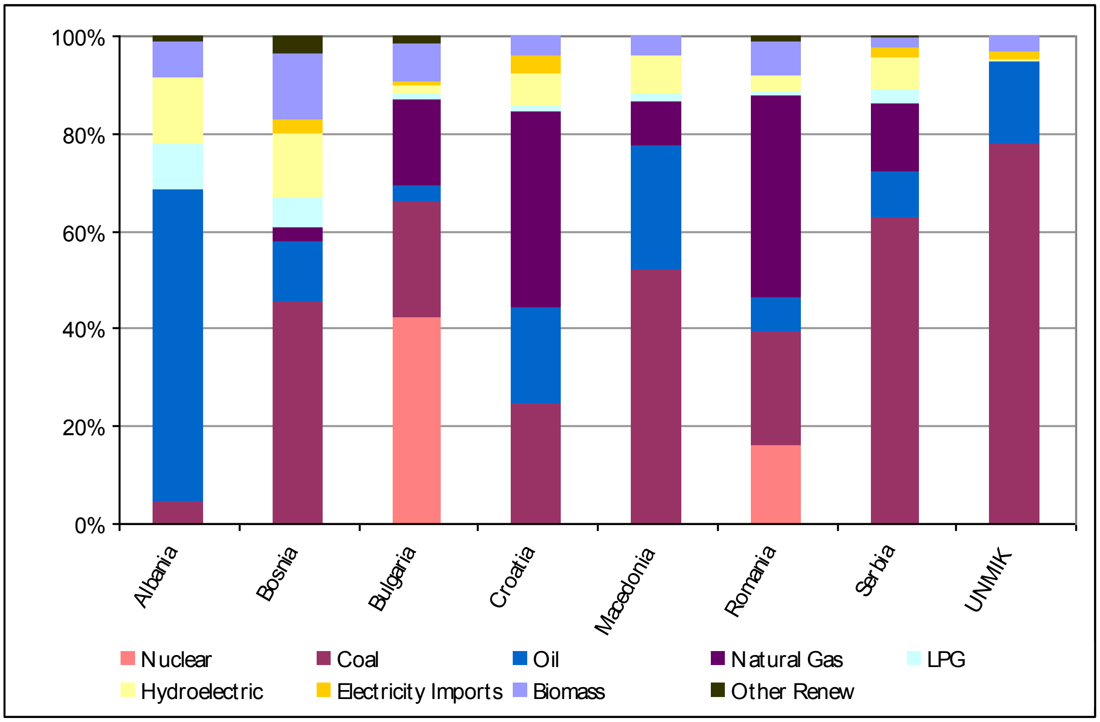


Figure 1-8: Composition of Energy Supply by Country in 2003



Energy System Costs. The total energy system cost encompasses all costs associated with the energy system, including expenditures on fuel, investments in new power plants and demand devices, and technology operation costs (other than fuel) over the 27 years of the planning horizon. As shown in Figure 1-9, the eight countries fall into three clusters based upon the size of their energy system: (i) Romania, (ii) Bulgaria, Croatia and Serbia, and (iii) Albania, Bosnia and Herzegovina, Macedonia and UNMIK.

Figure 1-9: Total Discounted Energy System Cost for the Region

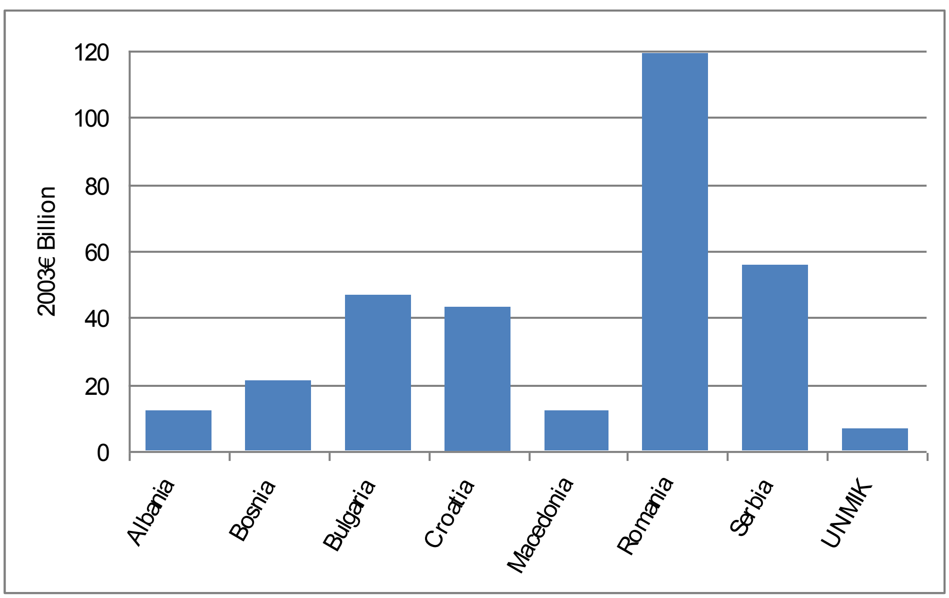
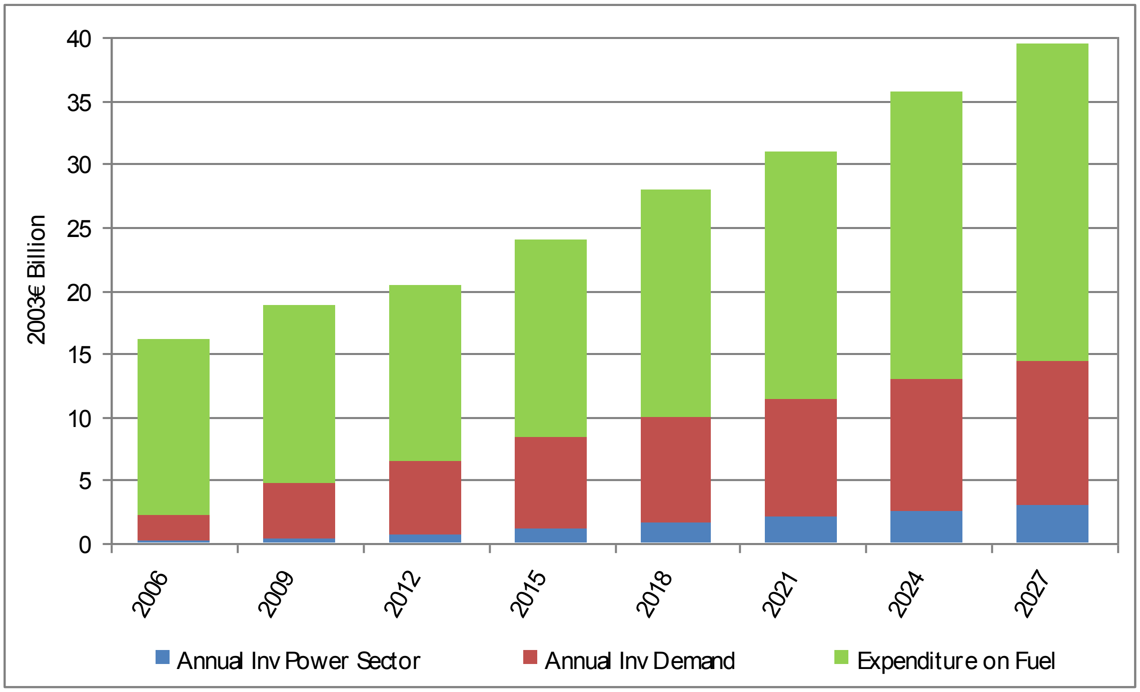


Figure 1-10 shows that the total energy system cost reaches nearly €40 billion per year in 2027. Fuel expenditures increase to €25 billion per year by 2027, 80% higher than 2006, and dominate the annual energy system cost. Annualized investments in technology reach almost €15 billion in 2027, with power plants comprising €3 billion and investment in demand devices requiring almost €12 billion, nearly four times the capital needed for power plants.

Figure 1-10: Aggregate Annual Energy System Expenditure for the Region



1.3 POLICY SCENARIO HIGHLIGHTS

A particularly robust dialog is underway in South East Europe regarding the role of energy efficiency in shaping the evolution of the energy systems in the region. The analysis presented in this report examines the trade-off between focusing primarily on supply-side solutions versus introduction of programs and policies to encourage investments in demand-side energy efficiency measures and thereby reduce necessary supply-side costs. The indicative policy analyses examine how investment strategies need to change -- as compared with the Reference scenario -- in order to promote increased energy security and economic growth, and indicate the resultant benefits in terms of energy security (less imports) and competitiveness (better energy intensity at acceptable cost).

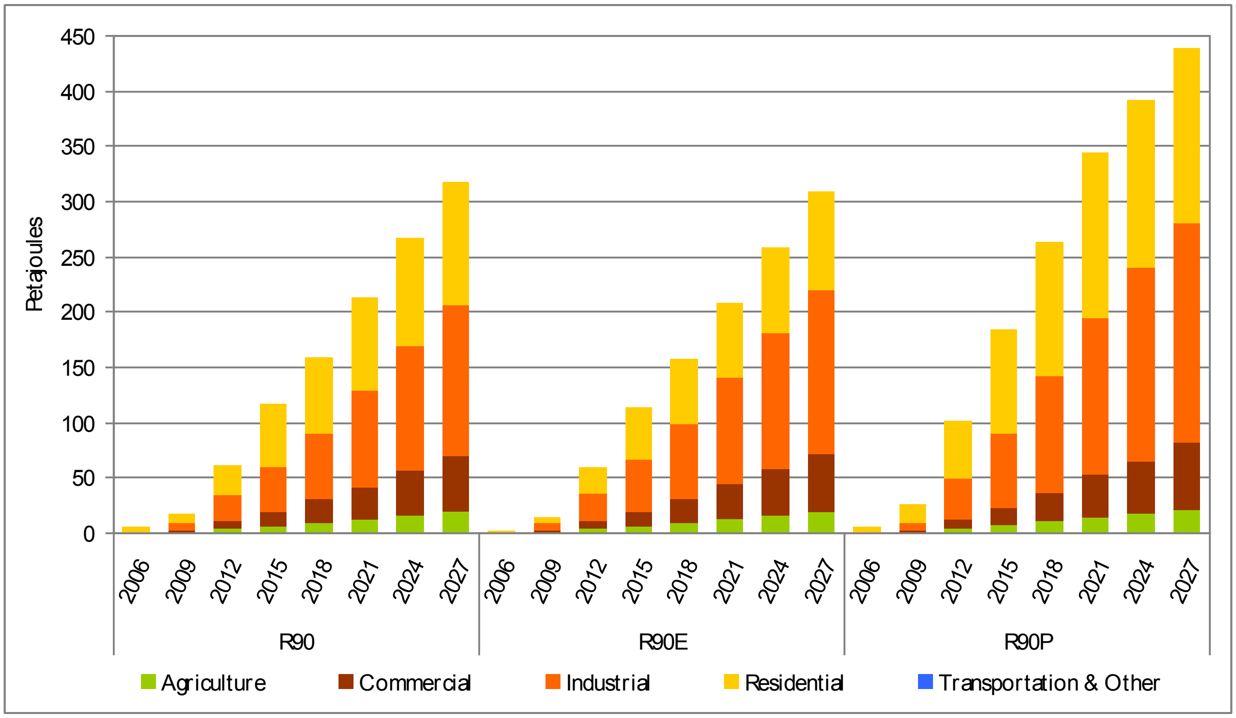
Table 1-2 lists the three indicative policy scenarios that were examined and gives the short scenario name that is used in many of the following figures. In general, the three scenarios represent progressively more demanding changes in the energy system, as their relative results illustrate.

Table 1-2: Efficiency Promotion Scenarios Examined

Scenario	Description
R0: Reference (BAU) Scenario	The presumed evolution of the energy system, where the current situation continues.
R90: Promoting Energy Efficiency	Increase access to energy efficient demand technologies.
R90E: Reducing Electricity Consumption	Impose a requirement of a 10% reduction -- from the Reference case – in electricity consumption.
R90P: Reducing Energy Intensity	Reduce overall energy intensity by forcing reductions in total energy consumption to the lowest level possible at the same energy system cost as the Reference case.

Final Energy Savings. Figure 1-11 shows the aggregate reduction in final energy consumption relative to the Reference case that results from the three energy efficiency policy scenarios. The most pronounced savings are in the industrial sector, followed by the residential sector. The residential sector is particularly affected by imposition of a policy to reduce electricity consumption, as more efficient air conditioners and furnaces are installed in households. The Reducing Energy Intensity (R90P) scenario encourages action on both on the demand and the supply side and thus more efficient power plants are selected, in addition to more efficient end-use technologies, and the greatest energy savings are achieved.

Figure 1-11: Aggregate Savings in Total Final Energy Demand by Sector for the Region



As one would expect, by country the biggest savings come from the larger energy consuming countries, as shown in Figure 1-12.

Figure 1-12: Aggregate Savings in Total Final Energy Demand by Country

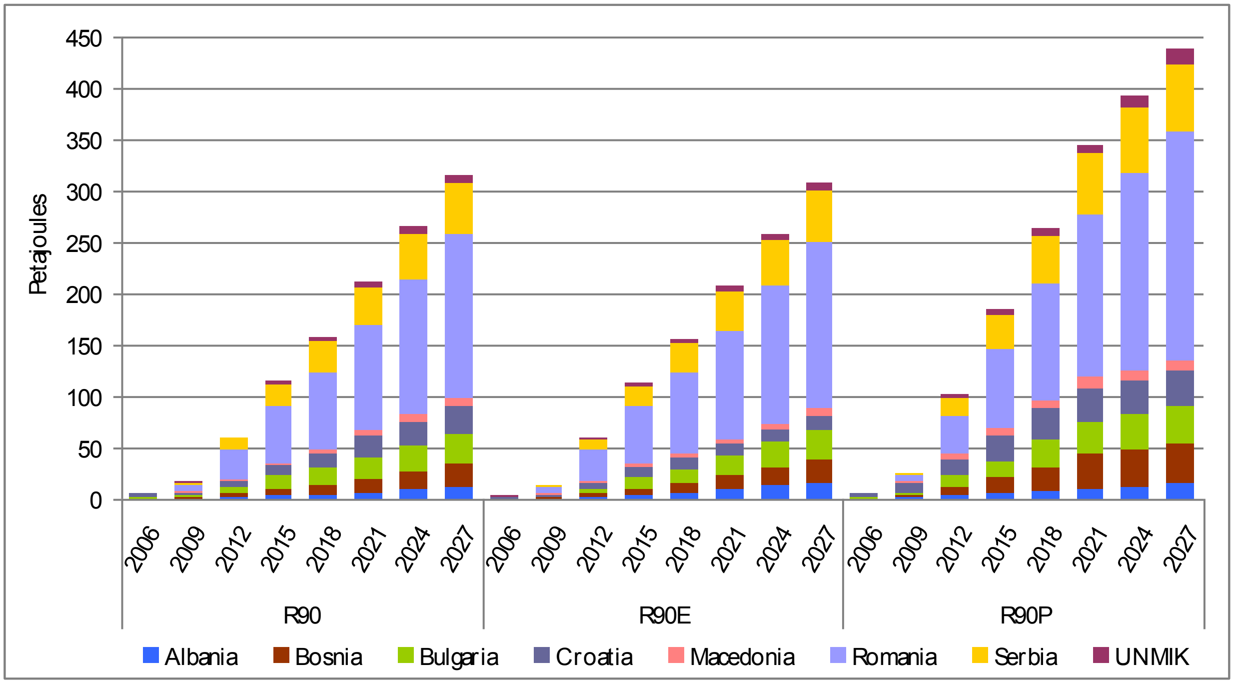
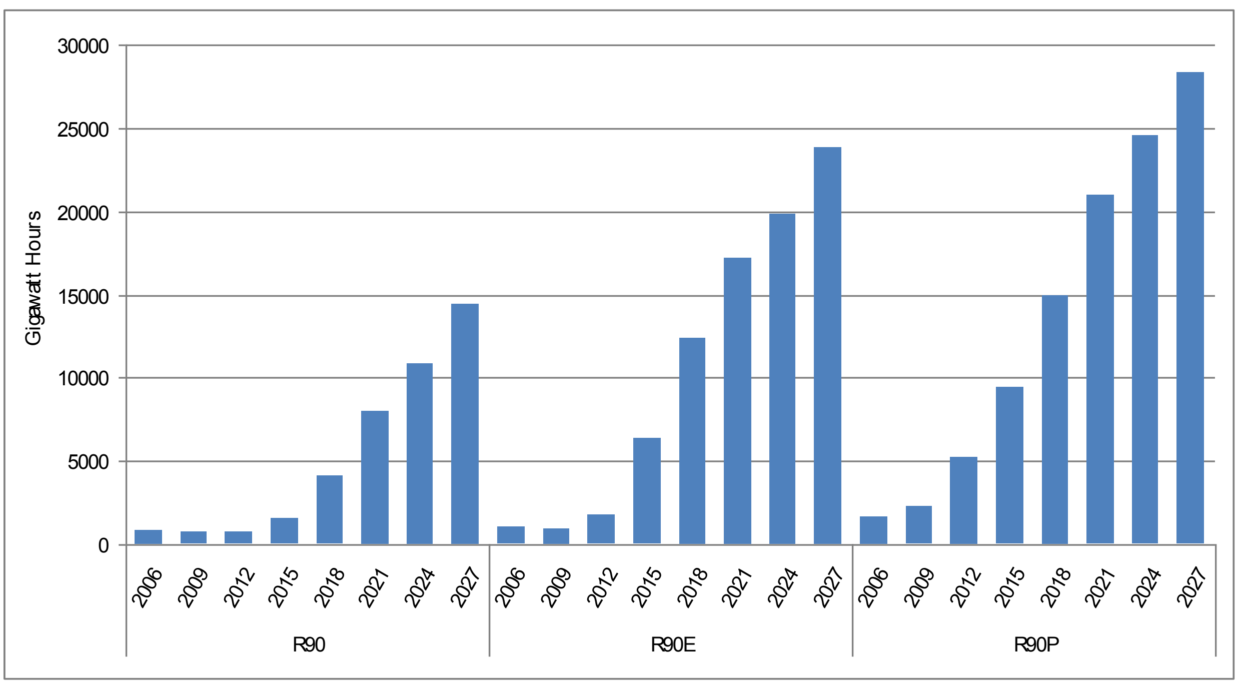


Figure 1-13 shows the aggregate saving in electricity consumption from the three scenarios. More electricity is saved in the R90P scenario, as the model looks to both the supply side and the demand side for the most cost-effective means to reduce the energy intensity of the system.

Figure 1-13: Aggregate Saving in Total Electricity Consumption for the Region



Electricity generation. The electricity generation mix shows an increased share coming from nuclear at the expense of coal-fired power plants. Promoting more efficient demand devices results in a 6% reduction in electricity use in 2027, while the forced 10% reduction in electricity use results in further reductions in coal-fired generation (mostly coal retrofit). The improved energy intensity scenario (R90P) reaches the same 10% reduction in electricity generation, adding more biomass-fueled power plants in lieu of coal plants.

Figure 1-14: Aggregate Electricity Generation by Fuel Type for the Region

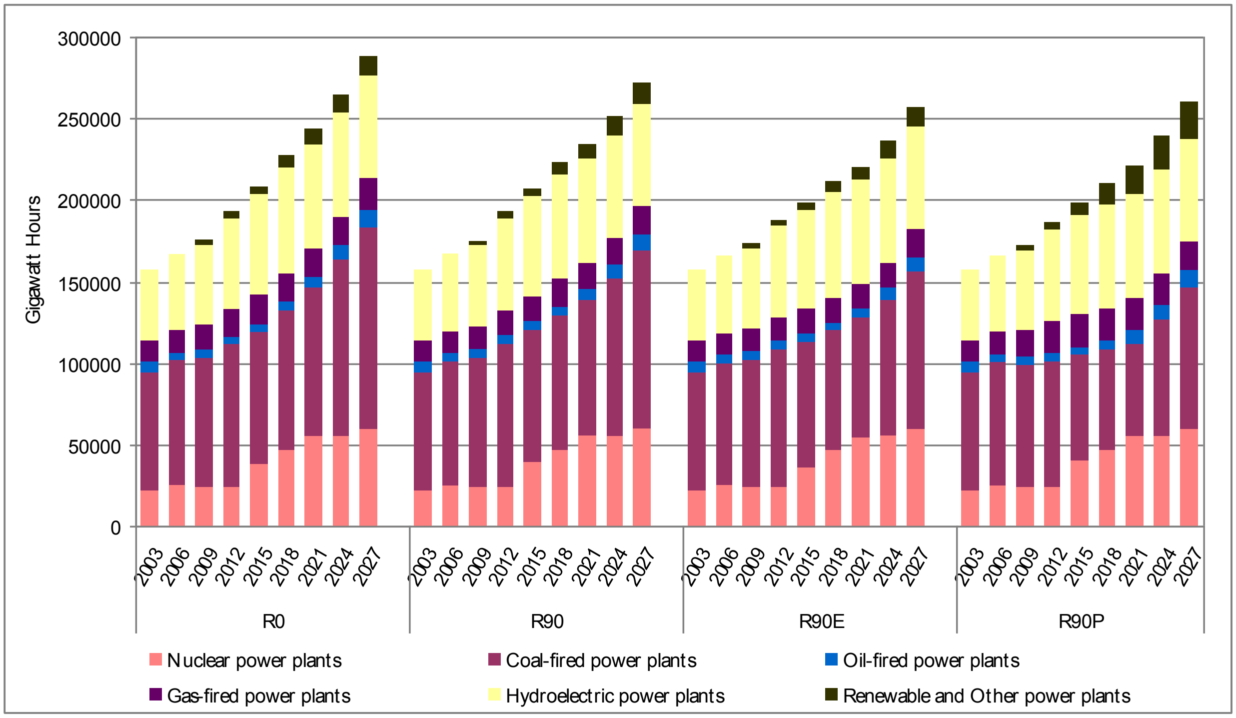
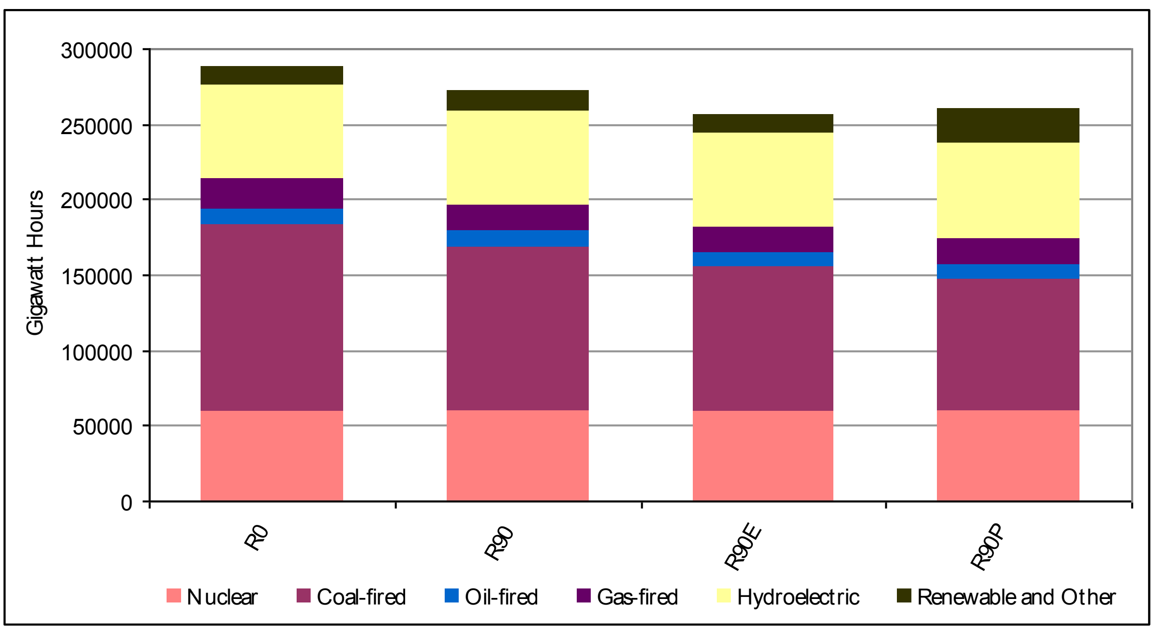
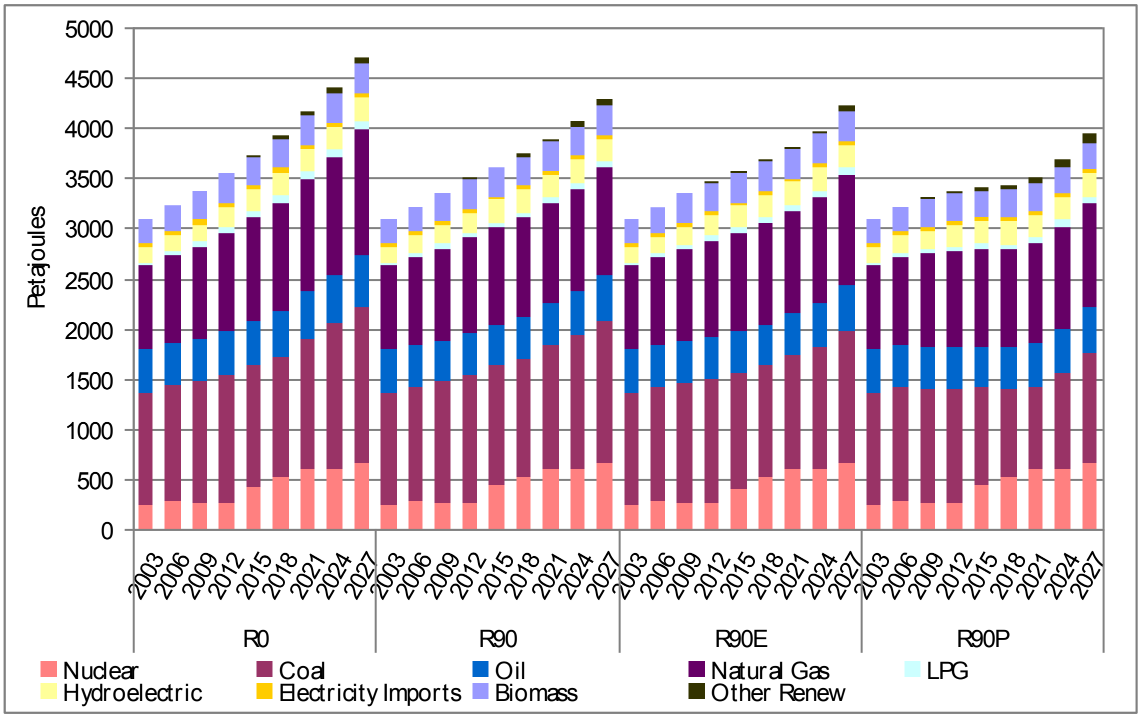


Figure 1-15: 2027 Electricity Generation Mix by Fuel Type for the Region



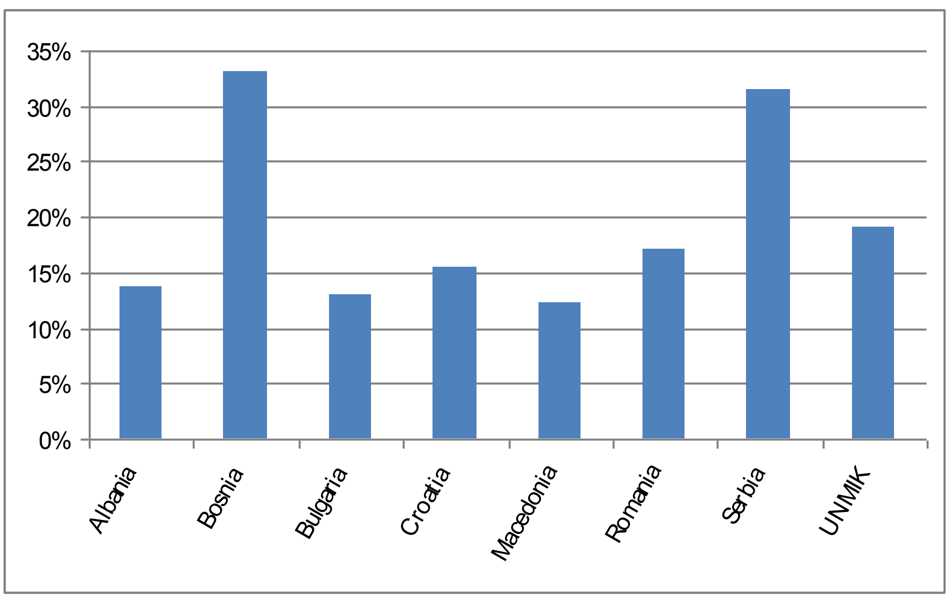
Primary Energy Savings. As measured by total supply, energy consumption in the three policy scenarios decreases from the Reference scenario by 9-18% by 2027. The main fuel shifts are a reduction in coal consumption, particularly in the R90P scenario as the system's overall performance is improved and additional nuclear capacity is installed in Bulgaria and Romania. (See Figure 1-14.)

Figure 1-16: Aggregate Total Primary Energy Supply for the Region



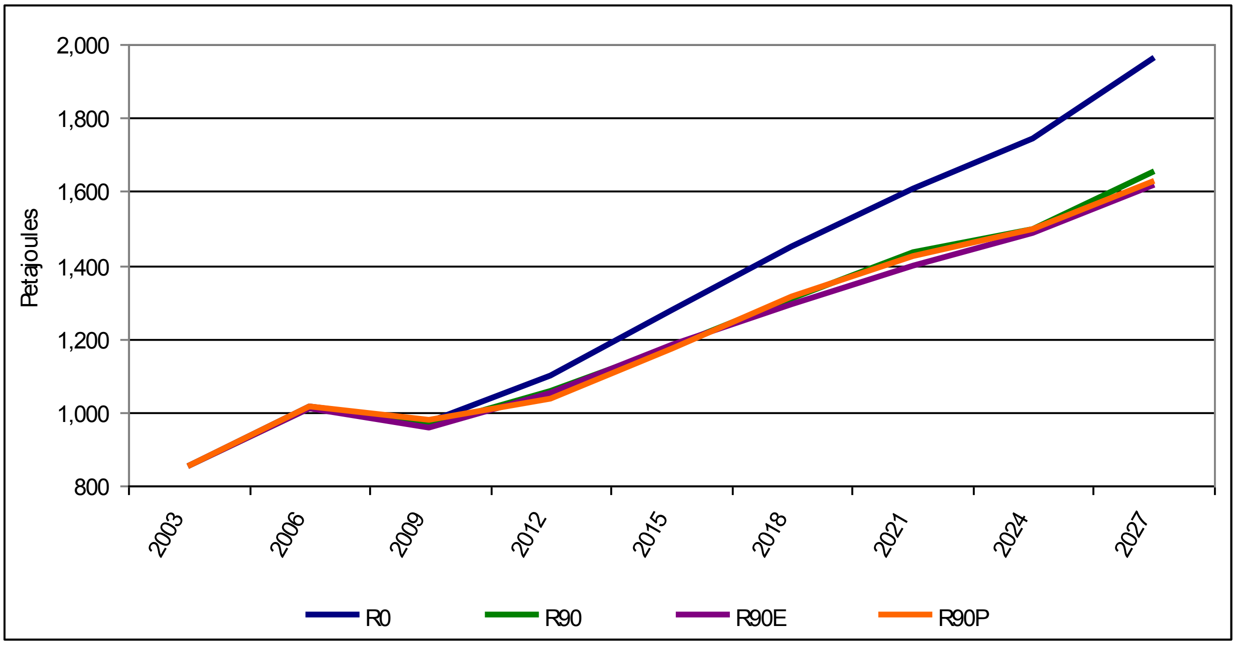
In the R90P scenario, the total level of improvement in energy intensity for the overall energy system is examined. As noted previously, by 2027 a 16% improvement for the region is possible at approximately the same total system cost as the Reference case. The range of that improvement by country is shown in Figure 1-17.

Figure 1-17: Reduction in Energy Intensity by Country



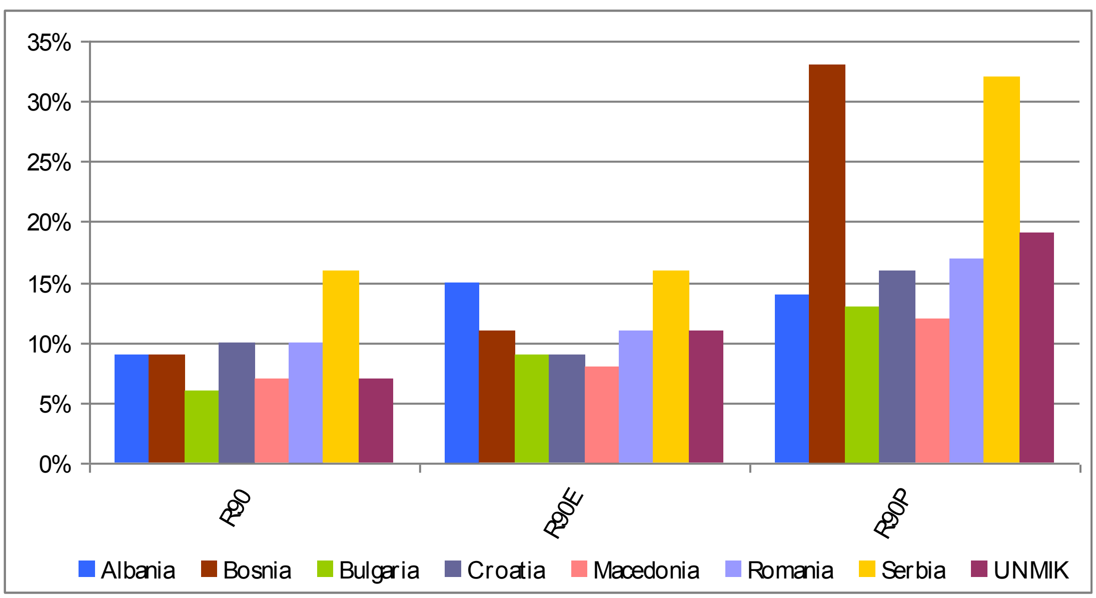
Energy security. A reduction of imports by more than 16% in 2027 across the three scenarios provides an indication that as consumption growth is tamed imports will tend to drop before domestic sources, improving overall energy security. As can be seen in Section 3, the majority of the drop in overall imports comes primarily from reduced imports of natural gas (into Croatia and Romania) and reduced levels of coal and oil coming into the other countries.

Figure 1-18: Level of Import for the Region



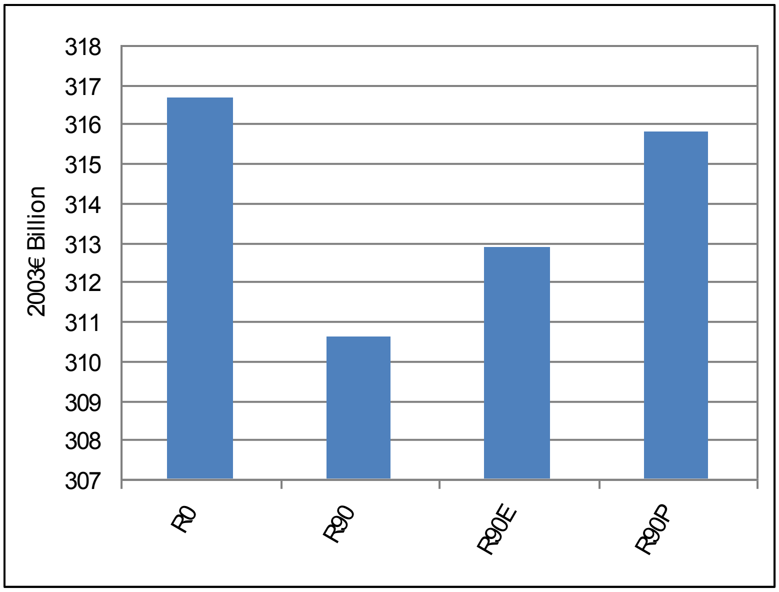
And as shown in Figure 1-19, in 2027 the drop in the share of total primary energy that comes from imports ranges from 6% in Macedonia to over 30% in Bosnia.

Figure 1-19: Drop in Imports' Share of Total Primary Energy by Country



Cost Savings. Substantial savings in overall energy system costs can be realized by promoting energy efficiency. The R90 scenario results in an overall energy system cost savings of €6.06 billion (1.9%) over the 27-year planning horizon, while the R90E scenario saves €3.78 billion (1.2%). In principle, the amount society saves in the R90/R90E scenarios can be earmarked for information campaigns, rebates, or subsidies and other policies to effectuate such changes. R90P has about the same system cost by definition, since the targeted level of energy consumption reduction in each country was pushed until the system cost approached that of the Reference scenario to determine the maximum "affordable" improvement in the energy system that can be achieved.

Figure 1-20: Aggregate Total Discounted System Cost for the Region



Relative to the Reference case, the three scenarios show the following changes in costs.

- Annualized investment in power plants decreases 8-15% (€246 - 455 million) in the R90 and R90E scenarios, but is about the same for R90P.
- Annualized investments for new demand devices increase significantly 14%, 22%, 28% (€1.59, €2.56, €3.16 billion annually by 2027) to achieve the policy goals represented by each scenario. The bulk of the more efficient investments is focused on commercial cooling and lighting, residential heating, and in the chemical and iron and steel industries.
- Fuel expenditures decrease significantly around 15% (€3.43, €3.36, €4.04 billion per year by 2027) in all three scenarios as the more efficient devices require less fuel. As is reflected by the decrease in overall system cost these savings more than offset the increased expenditures on new, more efficient devices.

Figure 1-21: Annual Expenditure on the Energy System for the Region

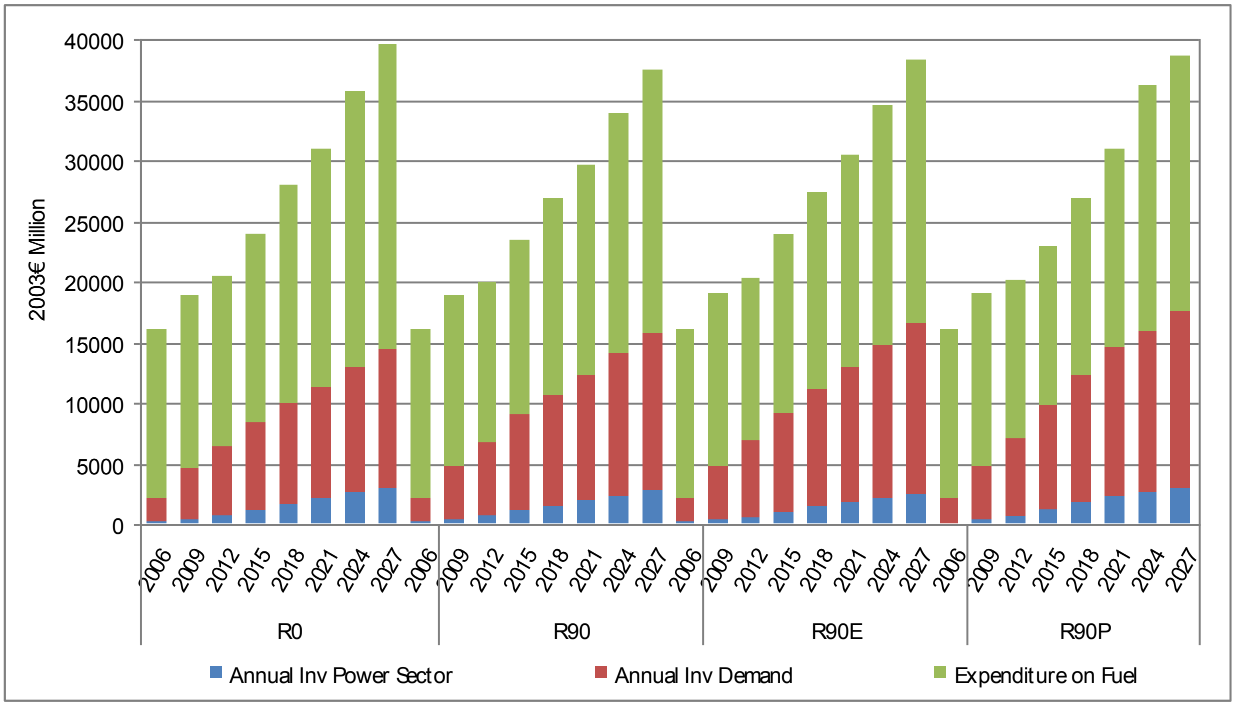
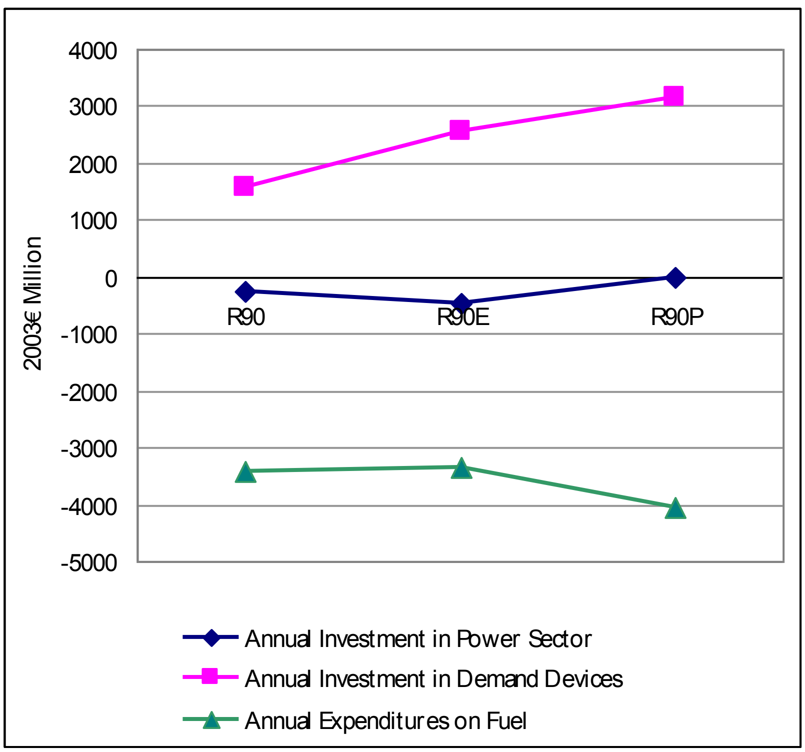


Figure 1-22: Change in 2027 Annual Expenditures



1.4 CONCLUSIONS AND NEXT STEPS

As a result of this project, robust national energy planning models have been developed and exercised in each of the REDP countries, the capacity of the TWG has been established, and a strong foundation has been laid for improved energy planning and better informed decision-making within the region. This report documents the nature of the energy system analysis that is now possible in these countries, as well as its value for informing policy discussions at both the national and regional levels. It does so by examining the benefits arising from programs that would encourage energy efficiency and conservation, providing estimates of the energy and financial savings that arise, estimating how much investment needs to be retargeted to enable such programs, and describing the resulting improved energy security (reduced imports) and intensity (less energy required per unit of GDP) profile that results. The range of key results for the three scenarios that examined the potential role of policies to encourage energy efficiency in the region is shown in Table 1-3.

Table 1-3. Benefits Arising from Increased Energy Efficiency

Improvement	Benefit Range (in 2027)
Total discounted energy system cost savings	1.5 - 2% (€3.78 - €6.06 billion) over the planning horizon
Change in undiscounted annual costs	
Power plant investment	Decrease of .2 – 15% (5 - 455€ million)
Demand-side investment	Increase of 14 – 28% (1.59 – 3.16€ billion)
Fuel expenditure	Decrease of 13 – 16% (€3.43/3.36/4.04 billion)
Annual energy savings	9 – 18% (417 – 793 PJ)
Annual electricity savings	6 – 11% (17 - 33GWh)
Reduction of imports	16 – 17% (309 – 343 PJ)
Decrease in energy intensity	9.4 – 18%

These models are invaluable tools that can allow policy makers in the region to explore energy system issues of most concern to them. The potential benefits are enormous – in terms of more efficient investment, enhanced energy security, increased environmental protection, and more targeted policies with fewer unanticipated impacts.

The potential for additional utility from these national models is also quite substantial. By adding the transportation sector and fuller emissions accounting, the underlying energy systems can be expanded to encompass the entire energy/environmental system. This would enable the models to better evaluate pathways to achieving enhanced energy security and (a subset of) the EU energy/environmental targets. Among the other areas that are candidates for subsequent application of the models are:

- Re-evaluating the potential role of energy efficiency and conservation in curbing growth in energy demand using data developed by the Energy Efficiency Task Force;
- Diversification and security of energy supply
  - The potential for renewables
  - Impacts of increased utilization of nuclear power
  - Optimal use of increased availability of natural gas;
- The effect of eliminating energy price "distortions;"
- Evaluation of requirements to support more rapid economic growth, and
- The potential benefits of regional electricity and gas markets.

As noted earlier, a limitation of the current framework is that each country is modeled separately; there is no endogenous trade of electricity or gas depicted. But these 8 country models can be combined into an integrated regional planning framework, providing a regional perspective while retaining national autonomy and specific details for each country. Furthermore, consideration should be given to promoting closer coordination with other ongoing undertakings in the region (e.g., Energy Community's Efficiency Task Force, South East European Co-operative Initiative (SECI)[7]), as well as any subsequent Generation Investment or Regional Gas assessments that may be undertaken, to further improve the ability to assess the pressing energy and environmental issues in the region. In addition, national models for other countries in the region – not currently in the REDP – can be added to the integrated regional model framework to expand its scope and value.

At the same time, the Ministries and Energy Community Secretariat must commit to sustaining and expanding the models, and plan to fully integrate the capacity now available to them into their national planning processes. This entails an ongoing commitment to keeping the model current, continually defining the issues that the model is to address, and providing the time/staff needed to enable each country's team to efficiently and effectively apply this tool.

7 "SECI attempts to emphasize and coordinate region-wide planning, identify needed follow-up and missing links, provide for better involvement of the private sector in regional economic and environmental efforts, help to create a regional climate that encourages the transfer of know-how and greater investment in the private sector, and assist in harmonizing trade laws and policies."(www.secinet.info)

INDIVIDUAL COUNTRY RESULTS

After significant time and effort by the TWG representatives country models are complete enough to conduct scenario analyses that examine key energy issues and policies that can shape the evolution of their energy systems. This Appendix presents the details of each country's Reference (current situation) scenario and the results of the analyses performed. Each team established their Reference scenario and ran their models for the three scenarios discussed in previously and summarized below.

Scenario	Description
R0: Reference Scenario	The presumed evolution of the energy system.
R90: Promoting Energy Efficiency	Increase access to energy efficient demand technologies.
R90E: Reducing Electricity Consumption	Impose a requirement of a 10% reduction -- from Reference scenario – in electricity consumption.
R90P: Reducing Energy Intensity	Reduction of the overall energy intensity by forcing reductions in total energy consumption to the level possible at the same energy system cost as the Reference scenario.

In addition, the TWG was encouraged to conduct one or two additional scenario assessments to examine issues of particular interest to their system (e.g., increased renewables, the possible role of nuclear).

C. BULGARIA

This Section C provides an overview of the Bulgaria energy system analysis. Section C.1 provides highlights of first the Reference scenario, followed by an overview of the Policy scenarios. Later sections provide more detailed discussion of both the Reference (C.2) and Policy scenarios (C.3).

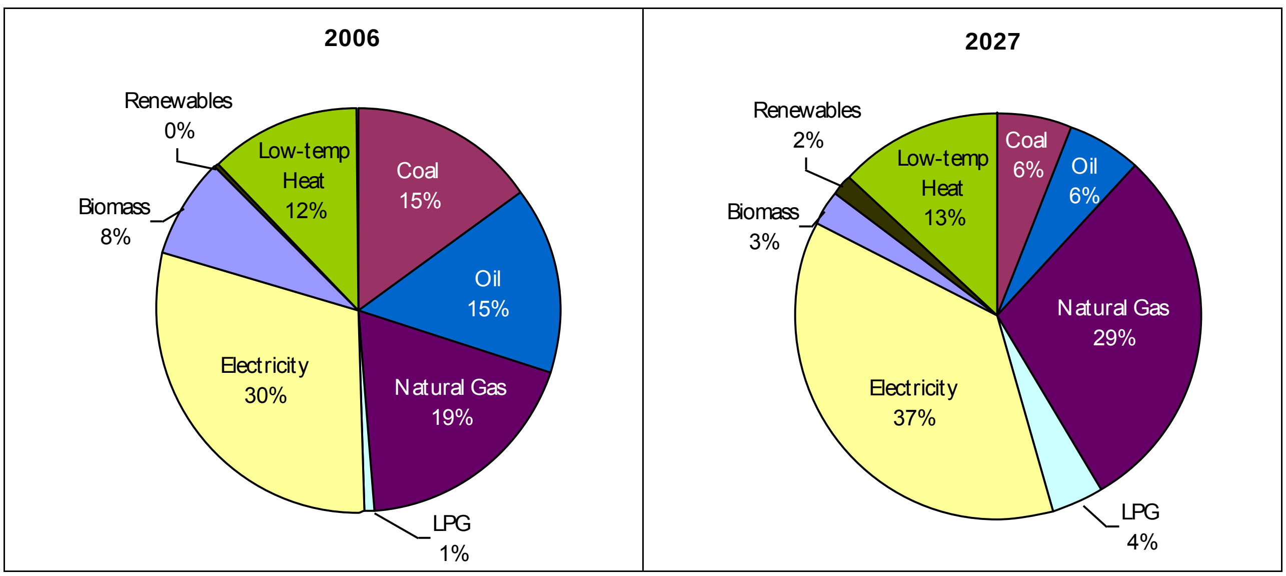
C.1 HIGHLIGHTS

C.1.1 REFERENCE SCENARIO

The evolution of the Bulgaria energy system under a Reference scenario is briefly summarized and illustrated in the charts below.

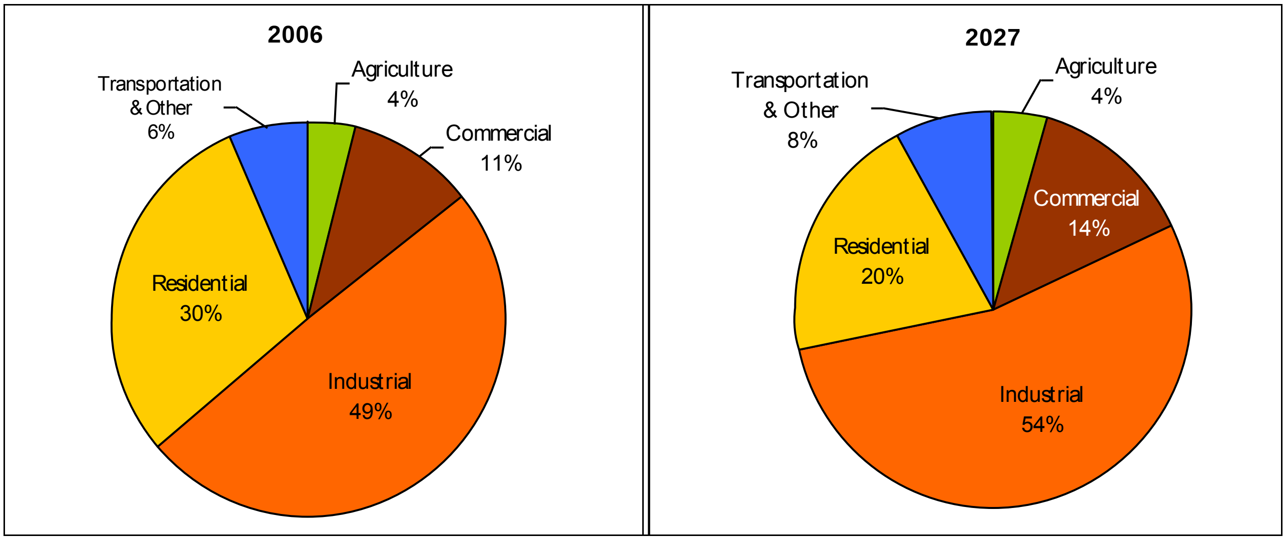
- **Final energy consumption** shows that total electricity share grows to 37% in 2027 (from 30% initially), owing to the addition of two new nuclear power plants, and the share of gas moves to 29% (from 18.7%), with shrinking shares of coal, oil and biomass.

Figure C-1: End-Use Fuel Consumption



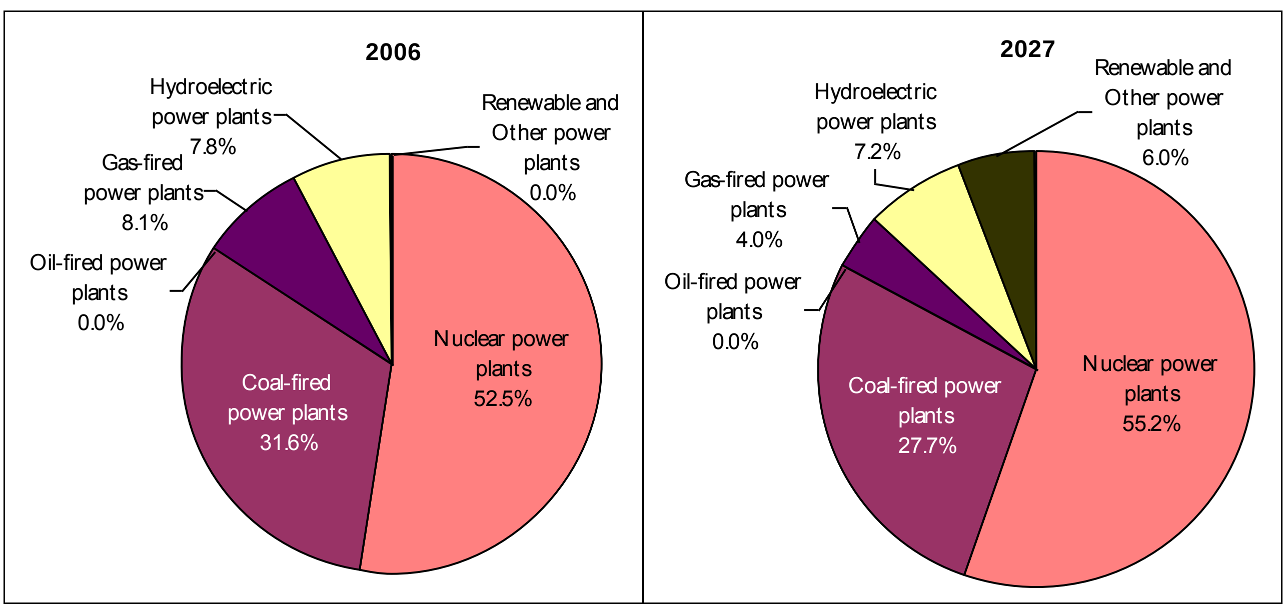
- **Final energy consumption by sector** shows that most growth in energy consumption occurs in the commercial and industrial sectors, with the residential sector demand shrinking both in absolute and percentage terms.

Figure C-2: Energy Consumption by Sector



- **Electric Generation** increases from 135 PJ (37,500 GWh) to 183 PJ (50,833 GWh) by 2027, a 35% increase. [Note that exports are capped at 2003 levels.] By 2027,
  - 55% of electric generation is provided by nuclear power plants;
  - 28% is from coal-fired power plants;
  - 6% is contributed by new non-hydro renewables (biomass, geothermal and a small amount of wind); and
  - contributions from hydro and gas-fired generation remain fairly stable near their 2003 levels.

Figure C-3: Electricity Generation



- **Primary Energy Supply** in the country increases by 16% by 2027
  - Nuclear energy provides the bulk of the additional energy requirements, increasing from 37.7% to 42%;

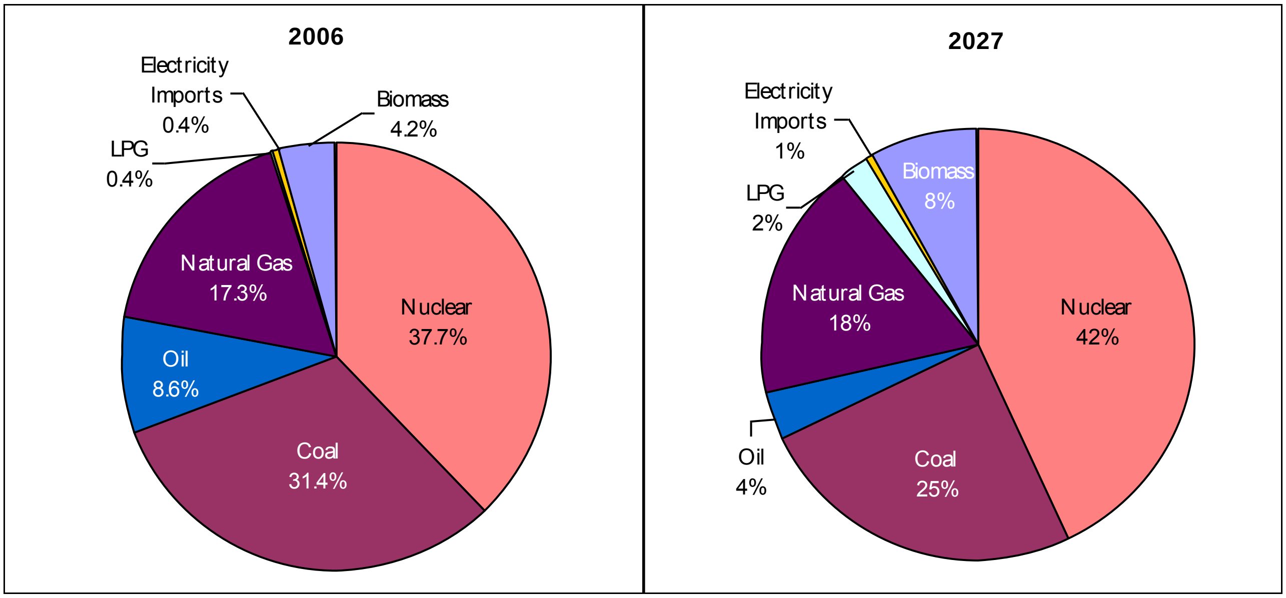
– coal usage drops from 31.4% to 25%;

– biomass use doubles to 8% of total supply;

– natural gas use holds fairly steady; and

– oil consumption (outside of the transportation sector) drops by 50%.

Figure C-4: Primary Energy Use



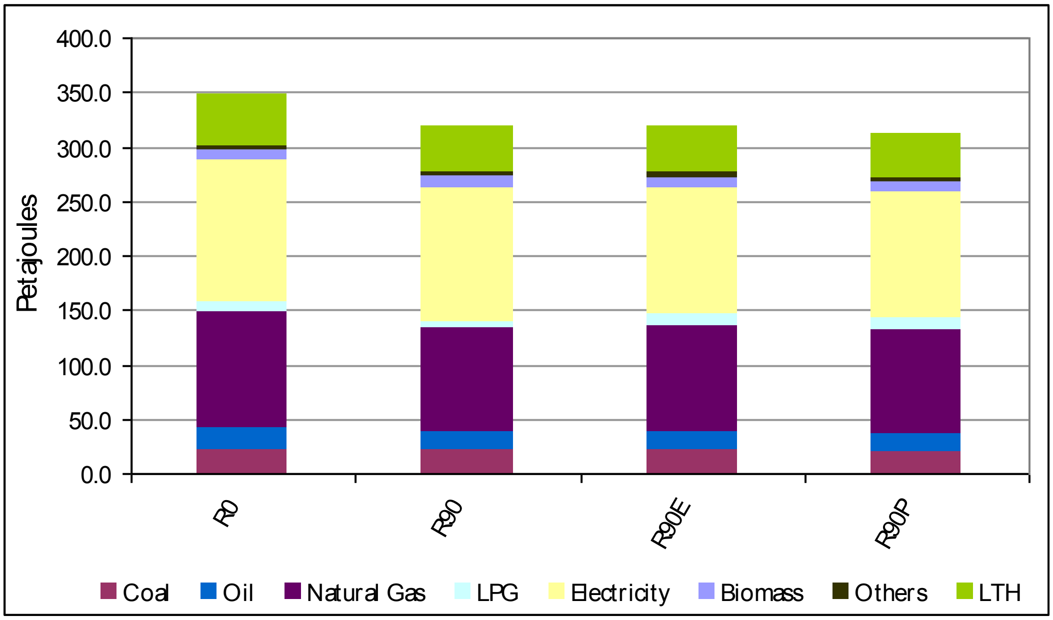
- **Fuel expenditures** increase to €1.98 billion per year by 2027, 26.5% higher than 2006, and dominate the energy system cost.
- **Annualized investments** in power plants and demand devices reach €1.588 billion in 2021 and €1.73 billion in 2027, with investment in demand devices absorbing 2.5 times the investment in power plants.

C.1.2 POLICY SCENARIOS

Providing increased access to energy efficient demand technologies, and further promoting their uptake by means of policies aimed at reducing electricity consumption or improving energy intensity (total consumption / GDP) result in various changes to the evolution of the energy system. The information below reflects the R90/R90E/R90P results, respectively. In general, the three scenarios represent progressively more demanding changes in the energy system, as their relative results illustrate.

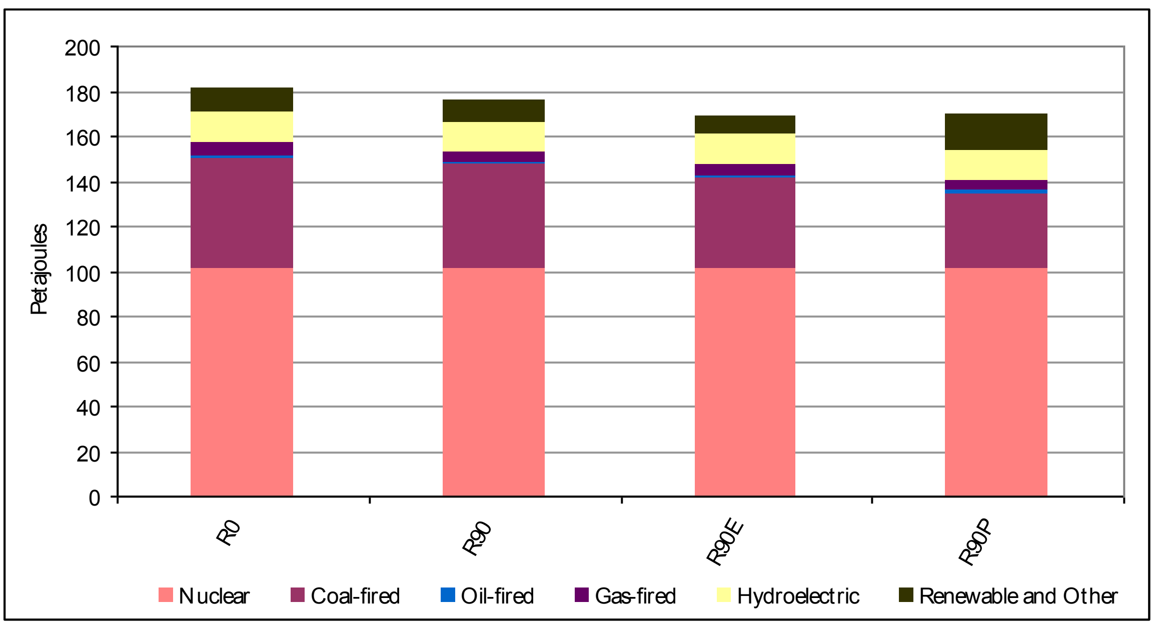
- **End-use Fuel Consumption** shows the most change in natural gas consumption, i.e., a reduction of 10% due to the improved efficiency of end-use devices introduced by three scenarios. Electricity also drops by 10% as expected in both scenarios (R90E and R90P) to 117 PJ compared to R90 scenario at 130 PJ.

Figure C-5: End-Use Fuel Consumption in 2027



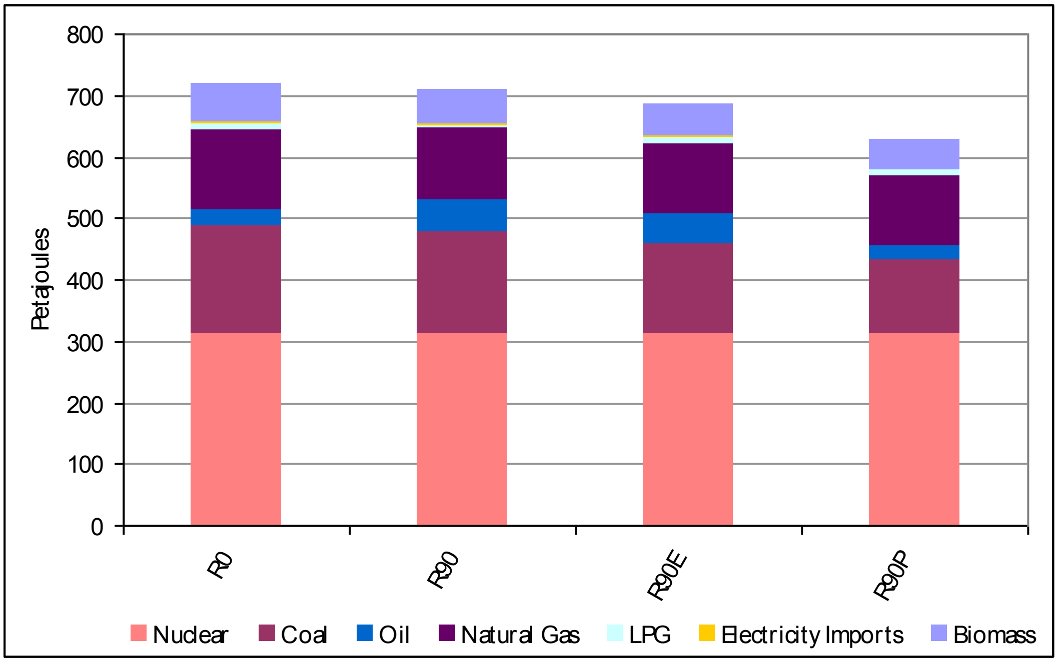
- **Electricity generation** shows less change owing to the substantial availability of nuclear power. Promoting more efficient demand devices only results in 4% reduction in electricity use, while the forced 10% reduction in electricity use results in a decrease in coal-fired generation (mostly coal retrofit). The improved energy intensity scenario (R90P) adds more biomass fueled power plants in place of coal plants.

Figure C-6: Electric Generation by Power Plant Type in 2027



- **Primary energy** use in the country decreases by 5/8/13% by 2027, with a corresponding improvement in energy intensity, where the main fuel shift is a reduction in coal consumption, particularly in the R90P scenario.

Figure C-7: Primary Energy Use in 2027



- **Energy imports** drop by 5.8/6.9/7.6% in 2027 for the three respective scenarios, which improves energy security.

- **Cost of the energy system** for the R90 scenario indicates an overall energy system cost savings of €391 million over the 27 year modeling horizon, and €183 million for the R90E. R90P has the same system cost by definition.

  Relative to the Reference case, the three scenario runs show the following changes in costs.

  – Annualized investment in power plants decreases slightly in the R90 and R90E scenarios, but increases by 11.5% (€56 million annually by 2027) for R90P as the system moves to more efficient power plants to improve overall energy intensity.

  – Annualized investments for new demand devices increase significantly (€132-203 million annually by 2027) to achieve the policy goals. The bulk of the more efficient investments are focused on commercial cooling and lights, the chemical and iron & steel industries, and residential heating.

  – Fuel expenditures decrease significantly (€240/217/291 million per year by 2027) in all three scenarios as the more efficient devices require less fuel relative to the Reference case. These savings offset the increased expenditures on new, more efficient devices.

Figure C-8: Total Discounted System Cost

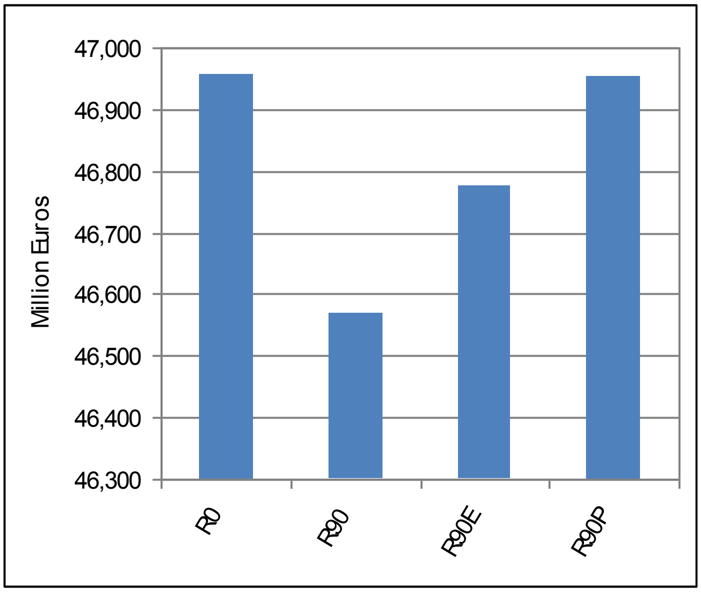
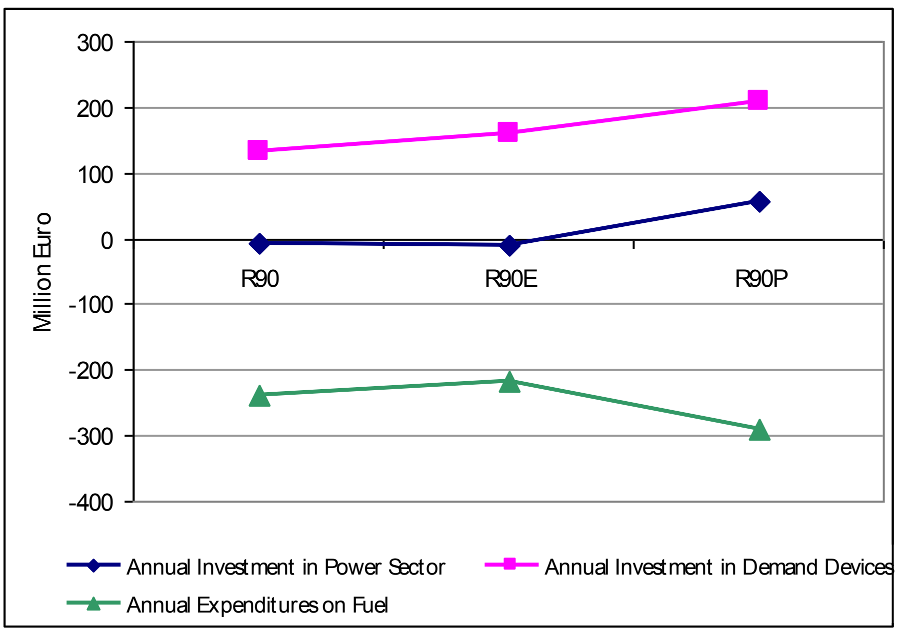


Figure C-9: Change in 2027 Expenditures Relative to Reference



C.2 ENERGY SYSTEM UNDER A REFERENCE SCENARIO

C.2.1 CRITICAL DRIVING ASSUMPTIONS

Figure C-10: Trend of Population and its Growth Rate

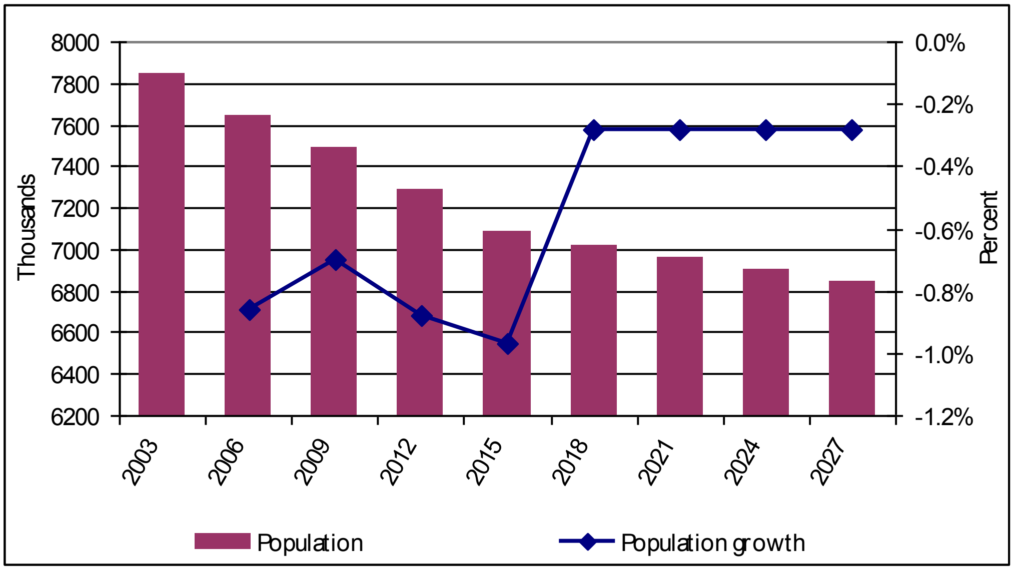
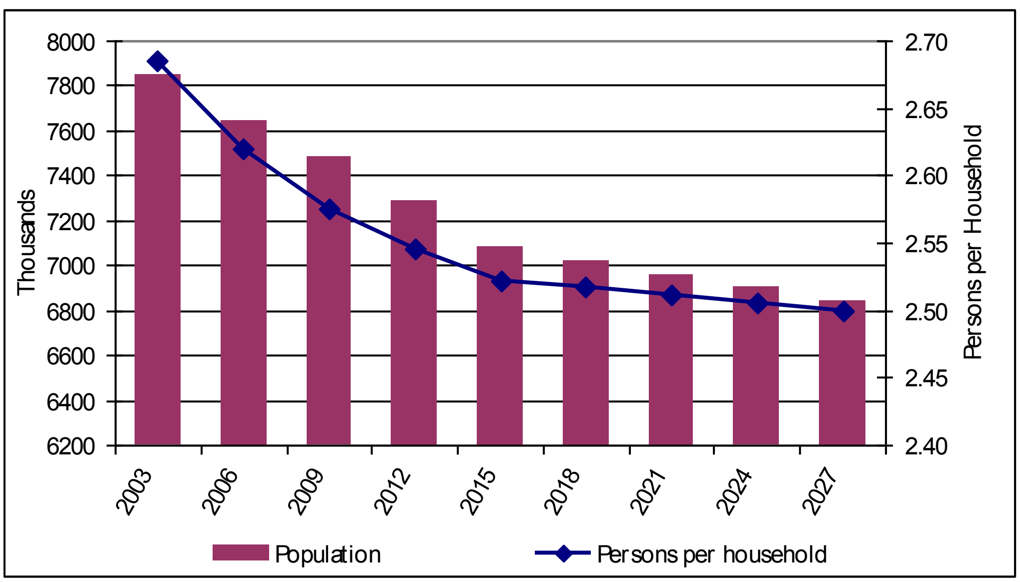


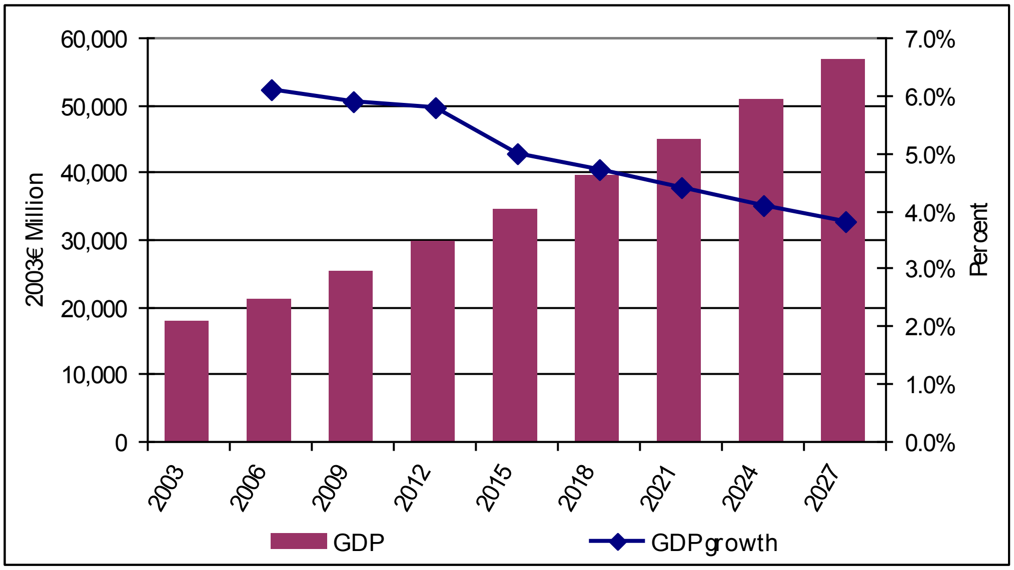
Figure C-11: Trend of Households and Number of Persons per Household



The forecast demographic trends for Bulgaria for the period 2003-2027 (falling population growth rates and declines in household sizes) are shown in Figures C-10 and C-11.

Figure C-12 shows a robust GDP growth rate of 6% per year falling to just under 4% by 2027.

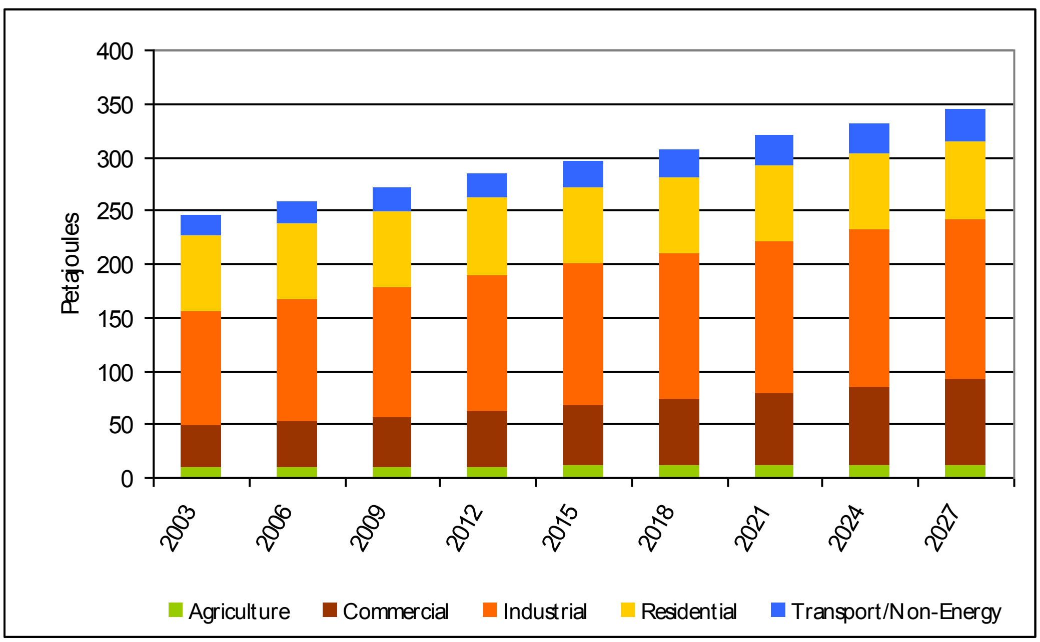
Figure C-12: Forecast of Total GDP and its Growth Rate



C.2.2 ENERGY SERVICE DEMAND PROJECTIONS

As discussed in Section 2.1 the demand for energy services over time serves as the primary driver for the requirements of the future energy system. These are derived by establishing the relationship between the fundamental drivers (discussed in the previous section), and their relationship via elasticities to the individual demands. The aggregate view of the demand composition is shown in Figure C-13 and each sector in discussed briefly in the sections that follow. The fastest growing sector is the commercial sector, where demand grows 100%, followed by the industrial sector with 40% growth.

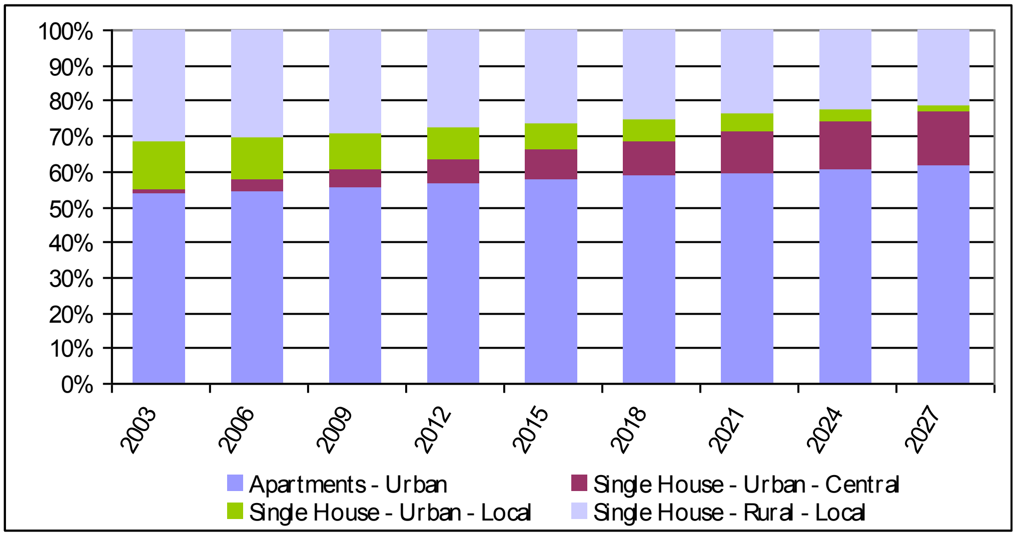
Figure C-13: Forecast of Energy Service Demand from each Sector



C.2.2.1 RESIDENTIAL SECTOR

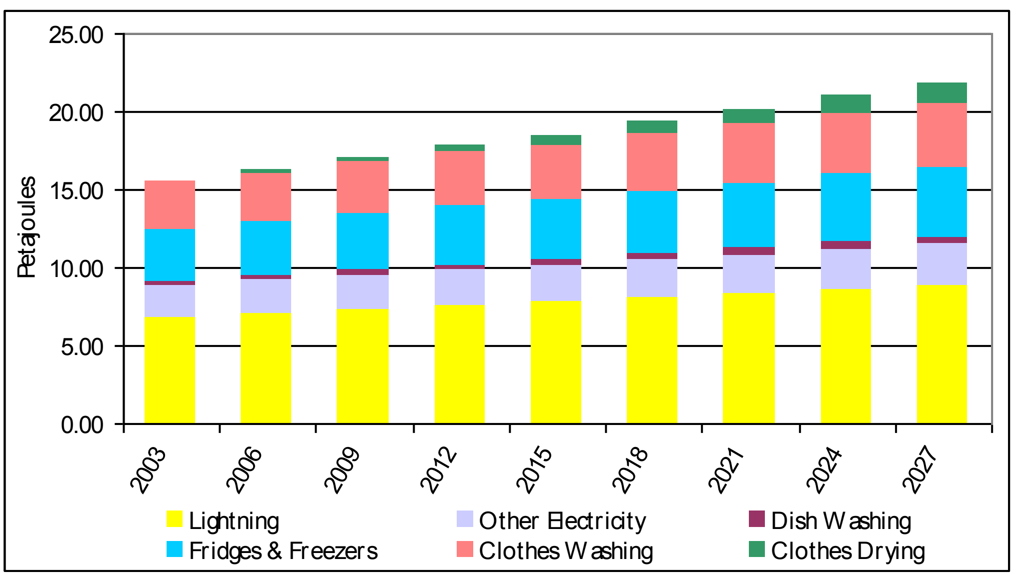
The main driving factors for calculation of energy demand in the residential sector are reduction in the number of households [see Figure C-10] and the evolution of residential living away from rural and towards more single family central urban dwellings, as shown in Figure C-14.

Figure C-14: Composition of Residential Dwellings over Time



The residential sector is second in importance with respect to energy today, though the commercial sector is expected to surpass it near the end of the study horizon. Figure C-15 shows how consumption in the residential sector is expected to decrease, mainly due to migration from rural housing to more efficient urban central dwellings.

Figure C-15: Residential Demand for Energy Services (Useful Energy)

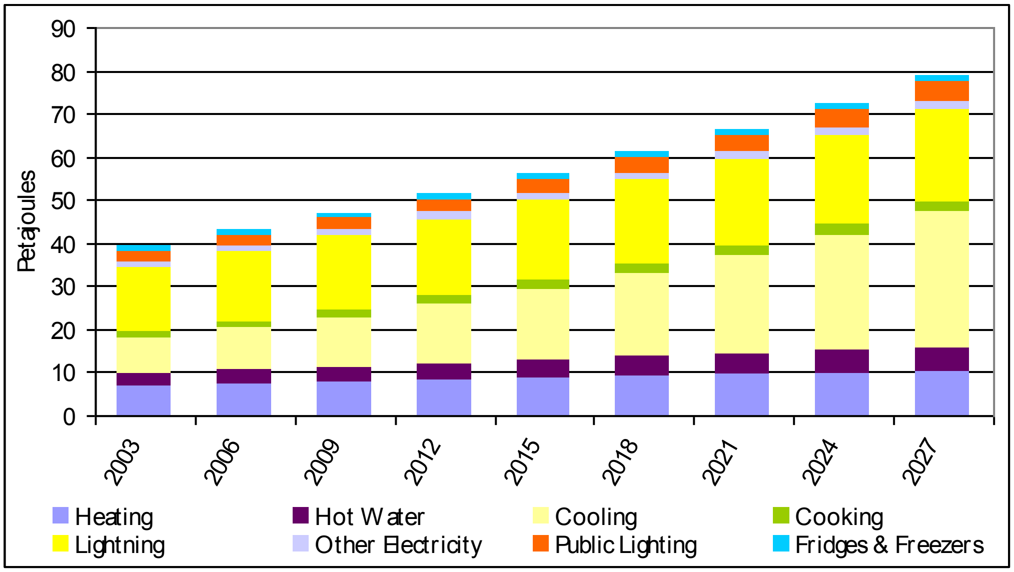


C.2.2.2 COMMERCIAL SECTOR

The commercial building stock is forecast to almost double across the Reference scenario time horizon, driven by evolution toward a service economy and higher standards of living.

In the Reference scenario, energy demand in the service sector will be 2 times higher in the year 2027 than in 2003, as reflected in Figure C-16. The major source of this growth is a fourfold increase in space cooling demand, with increases on the order of 50% for the other energy services.

Figure C-16: Commercial Demand for Energy Services (Useful Energy)



C.2.2.3 INDUSTRIAL SECTOR

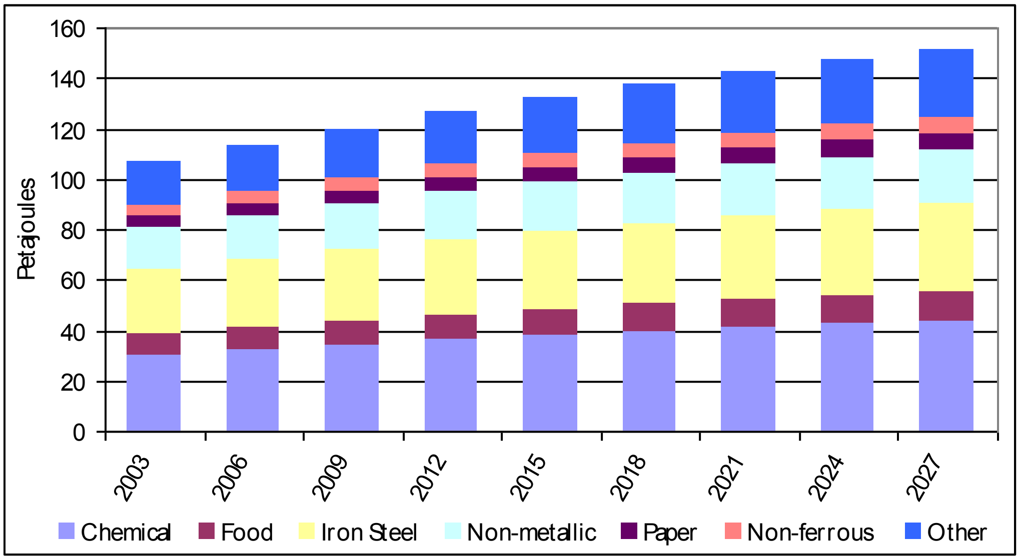
The driving factor in forecast energy demand in the industrial sector is the estimated contribution to GDP, which is mapped to increase in service demands in the various sectors by means of elasticities which relate future GDP growth to each sector's demand growth. This growth is moderated by an autonomous energy efficiency improvement (AEEI) factor as noted in Table C-1 that indicates non-technology improvements (e.g., management practices and process changes).

Table C-1: Demand Elasticities

Demand Type	Elasticity	AEI	Overall growth
High-temperature heat	0.50	0.015	27%
Low-temperature heat	0.60	0.010	60%
Mechanical drive	0.60	0.005	80%

The resulting demand growth is shown in Figure C-17. Chemical and Other are the fastest growing industrial demands, Iron and Steel, Paper, and Non-metallic Minerals are the other growing industrial demands. Overall industrial demand grows more slowly than the commercial sector, increasing 40% over the forecast horizon.

Figure C-17: Industrial Demand for Energy Services (Useful Energy)



C.2.2.4 AGRICULTURE

As in industry, agricultural energy demands are projected by means of an elasticity relating demand growth to GDP growth. For Bulgaria, an elasticity of 0.60 was used, resulting in a 80% growth of energy service demand. Agriculture remains a small portion of total energy service demand, as shown in Figure C-17, above.

C.2.2.5 TRANSPORT AND NON-ENERGY USE

Electricity demand for transport is projected based on population growth, and hence decreases by 9% over the forecast period. However, non-energy demand for gas (consumed for fertilizer) increases by 50% by 2027.

C.2.3 ENERGY SUPPLY AND PRICES

Figure 2-2 in the Regional section shows the trend of energy prices based on the EU NEEDS Project. These trends are applied to recent energy prices in Bulgaria to produce forecasts of future prices across the time horizon of this study. As noted earlier, it is assumed that the countries of the region will be confronted by the prevailing EU prices soon, so any country differentials at the border are removed beginning in 2015.

Besides the border price influencing the price seen by the consumer for each energy form, a distinction is made with respect to internal distribution costs to the different sectors. The "mark-ups" is based upon the situation in 2003, shown in Table C-2 below, and held constant over the planning horizon.

Table C-2: Sector Fuel Price "Mark-Ups" (M2003€/PJ)

	Sectors			
Fuel	**Residential**	**Commercial**	**Agriculture**	**Industry**
Hard Coal	1.490	1.490	1.490	0.000
Brown Coal Briquettes	3.149	3.149	3.149	-1.125
Lignite				0.000
Light fuel	13.575	13.575	13.575	
Heavy fuel	5.216	5.216	5.216	-0.158
LPG				
Gas	2.738	2.131	2.738	0.107
Electricity	2.024	1.012	2.024	
Low-temperature heat	0.000	0.219	0.000	0.437

Domestic supply increases only slightly, with the exception of the potential for lignite, which doubles over the modeling horizon, as reported in Table C-3. Most imports that occur currently are assumed to be unlimited in the future, with the exception of electricity which is capped at its 2003 level and natural gas where the basic supply and internal distribution system is capped at current levels subject to additional investment, if needed.

Table C-3: Upper Limits on Domestic Resource Supply (PJ)

Domestic Supply	2003 - 2027
Biomass	28.92 - 42.73
Brown Coal Briquettes	21.48 – 0.0
Coke	42.37 - 62.6
Distillate	62.89 - 92.92
Electricity Export	24.3-24.3
Electricity Import	5.071-5.071
Gasoline	26.58 - 35.62
Hard Coal	0.88 – 0.88
Heavy Fuel Oil	133.59 - 179.02
Kerosene	6.88 – 9.22
Lignite Coal	194.77 - 417.51
LPG	4.9 – 6.56
Natural Gas	0.54 – 0.54

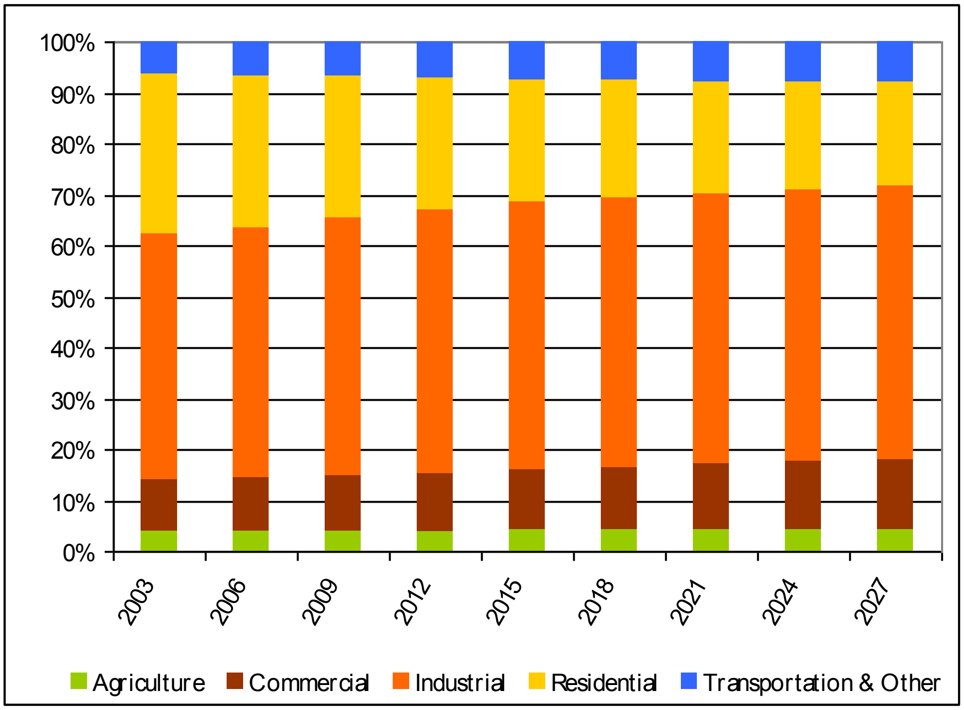
C.2.4 REFERENCE SCENARIO HIGHLIGHTS

The previous sections provided insight into the basic assumptions that shape the expected demand for energy services. But it is left up to the model to develop a depiction of the energy system under business-as-usual conditions to determine the future demand for final energy (e.g., electricity, heat, and natural gas), the power sector generation mix, and the assortment of technologies that are deployed over the planning horizon. This least-cost configuration of the energy system, within the limits of the constraints imposed (e.g., resource limits, rates of fuel switching, availability of advanced efficient devices), serves as the Reference scenario against which the alternate scenario analysis is compared. In this section the Reference scenario results are described.

C.2.4.1 FINAL ENERGY CONSUMPTION

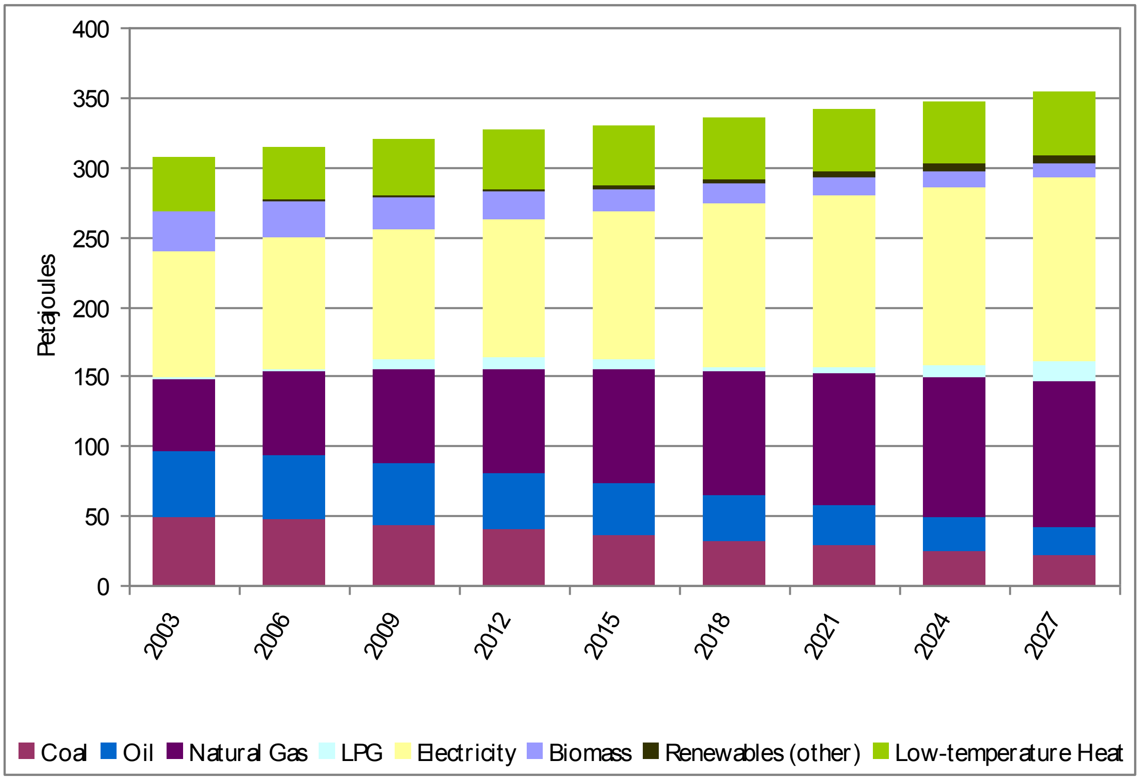
Final energy consumption increases over the years, which is consistent with the GDP growth. Final energy consumption increases in all sectors with the exception of residential, which decreases due to negative population growth and the expected migration of residential households to other European countries. The industrial sector dominates total energy consumption. Figure C-18 depicts final energy consumption by sector.

Figure C-18: Final Energy Consumption by Sector Share



In terms of final energy choices, total electricity share grows to 37% in 2027 (from 29% initially) owing to the addition of two new nuclear power plants, and the share of gas moves to 29% (from 17%), with shrinking shares of coal, oil and biomass. Biomass usage drops as less biomass is utilized in combined heat and power planed coupled with residential use of biomass diminishes. Figure C-19 depicts final energy consumption by fuel type.

Figure C-19: Final Energy Consumption by Fuel

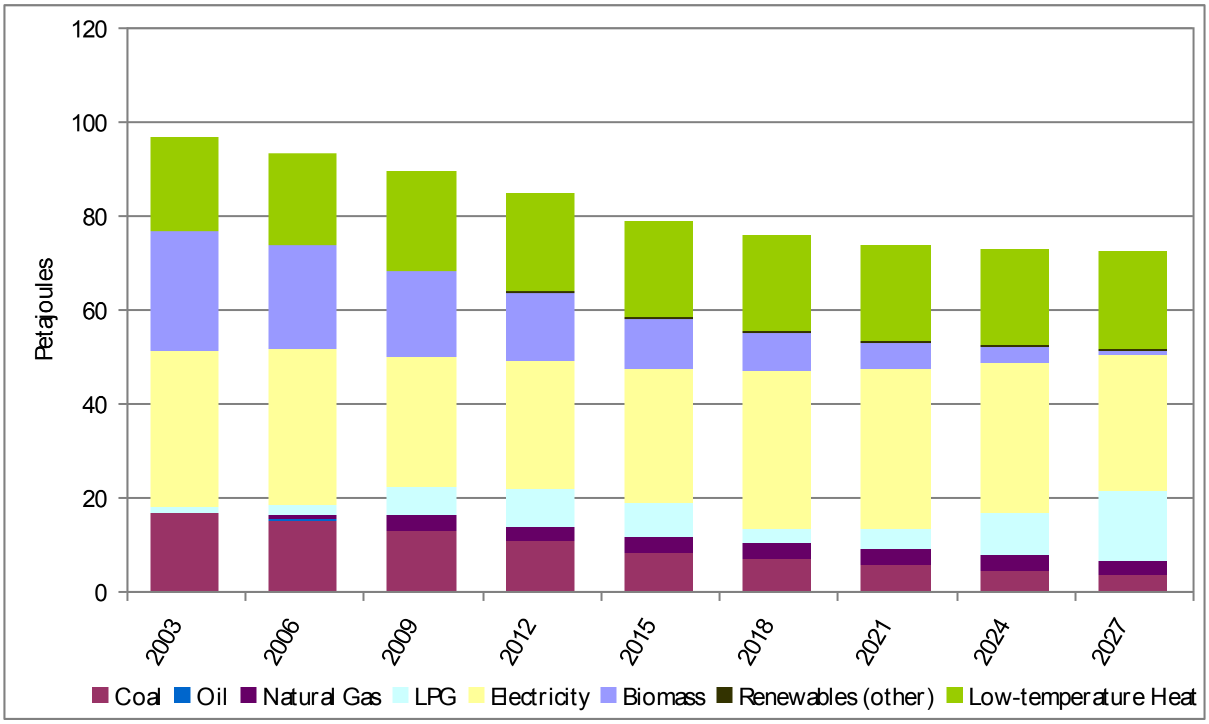


More detail is provided on the composition of final energy delivered to each sector in the sections that follow.

C.2.4.1.1 Residential Sector

As already noted, the demand for energy in the residential sector is expected to drop as much as 25% owing to the decrease in population, and improved building shell associated with the changing stock of housing. In terms of fuel choice, there is a transition from coal and fuelwood to electricity for space heating. In addition, the sector experiences an increase in the penetration of electric appliances and rapid acceptance of air conditioning. LPG growth is second to that of electricity, while the district heating system remains steady. As a result electricity in the residential sector grows slightly to 40%, with a peak of 46% when the new nuclear plants first come online. During the lean nuclear years and in the out years LPG picks up the remaining increase in rural heating and urban hot water demands. Figure C-20 depicts final energy consumption in the residential sector.

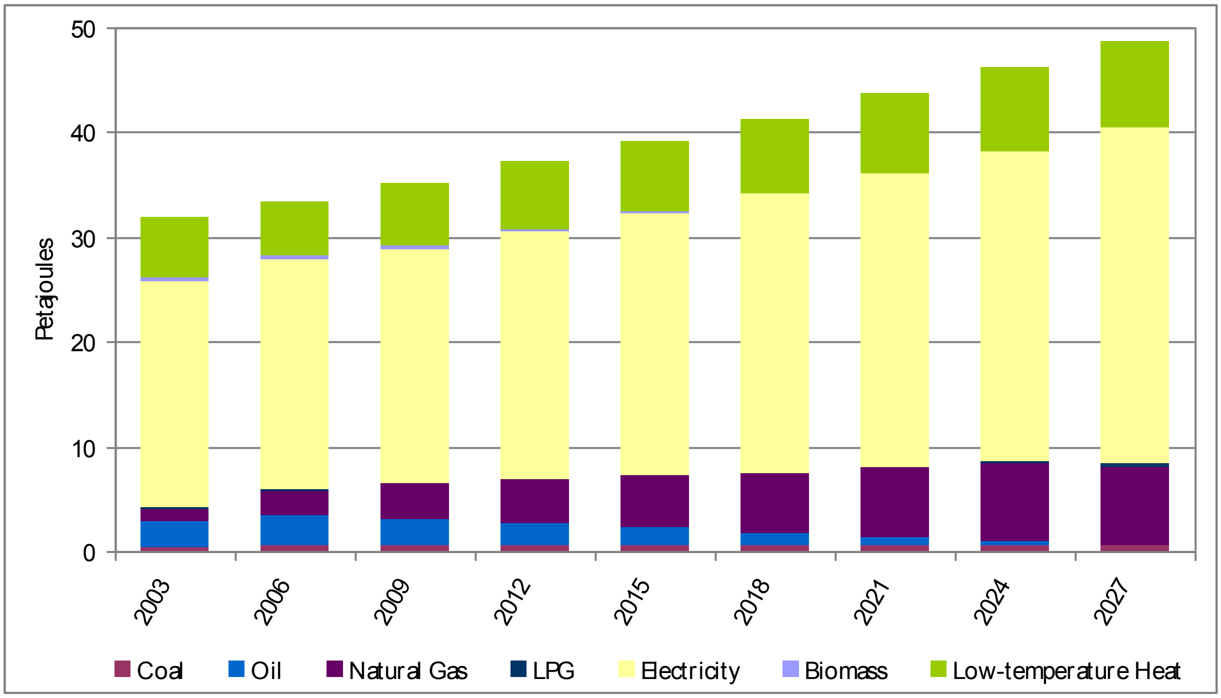
Figure C-20: Final Energy Consumption - Residential



C.2.4.1.2 Commercial Sector

The commercial sector is experiencing the most rapid growth of all the sectors, with final energy demand increasing by some 54%. As noted earlier, a substantial part of this is due to commercial air conditioning demand rising in earnest beginning 2012 (to a total of 75% by 2027), thereby dramatically increasing demand for electricity within the sector. Natural gas also makes an increasingly important contribution to meeting the heating and hot water demand, moving from 4% to 15% of total final energy to the sector. Due to availability and use of natural gas, oil consumption drops to zero by 2027. Figure C-21 depicts final energy consumption by the commercial sector.

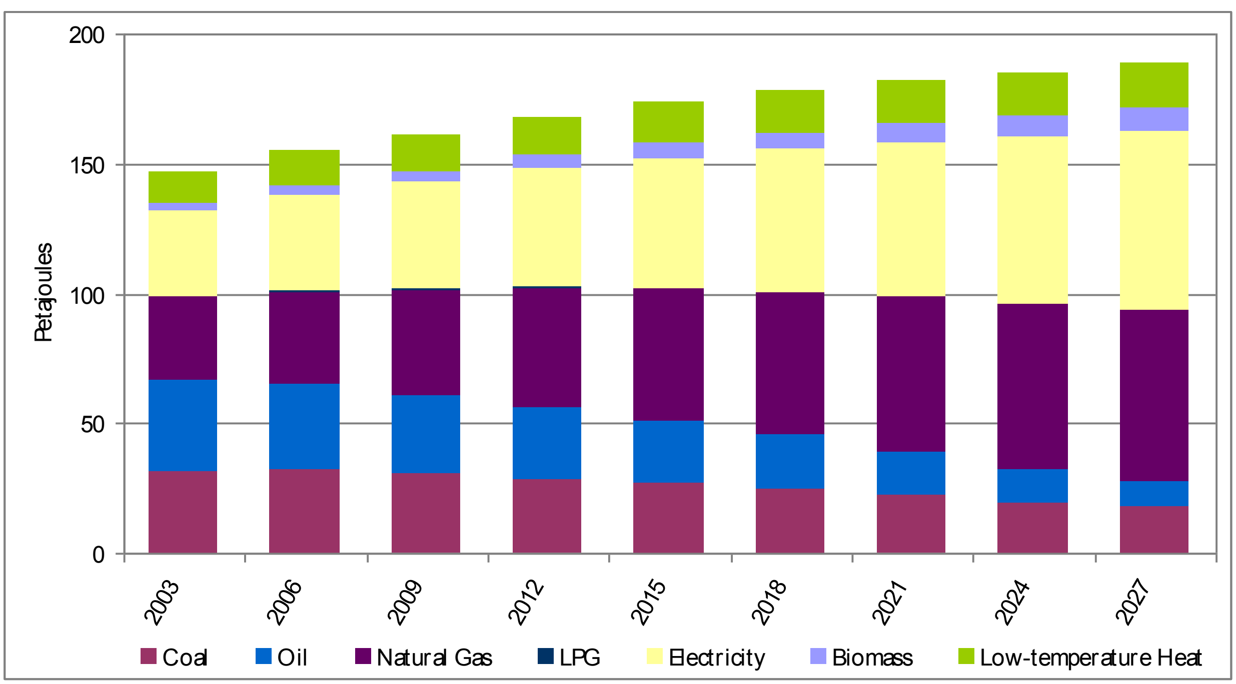
Figure C-21: Final Energy Consumption - Commercial



C.2.4.1.3 Industrial Sector

In the Reference scenario energy demand for industry will increase 31% by 2027. The evolution of the fuel mix for industry is shown in Figure C-22. As was the case in the commercial sector, the low electricity prices and gas distribution capacity have the industrial sector increasingly turning to these fuels, displacing oil and coal consumption. Interestingly there is also an uptake in biomass in the industrial sector to provide high-temperature heat to the food and chemical industries.

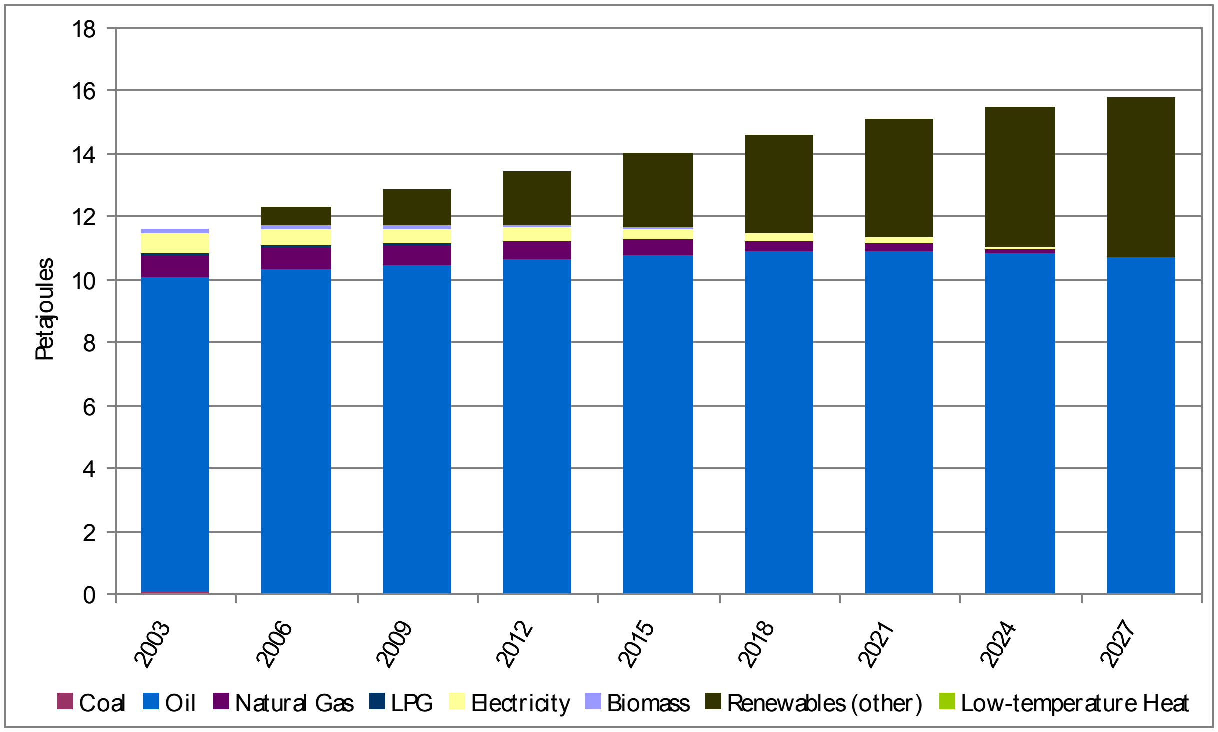
Figure C-22: Final Energy Consumption - Industry



C.2.4.1.4 Agriculture Sector

Figure C-23 shows the evolution of the principal fuels used in the agricultural sector for the Reference scenario. Diesel consumption is foreseen to increase considerably in the future to support agricultural production growth and replace manual labor. There is also some potential for geothermal to be used for heating greenhouses.

Figure C-23: Final Energy Consumption - Agriculture



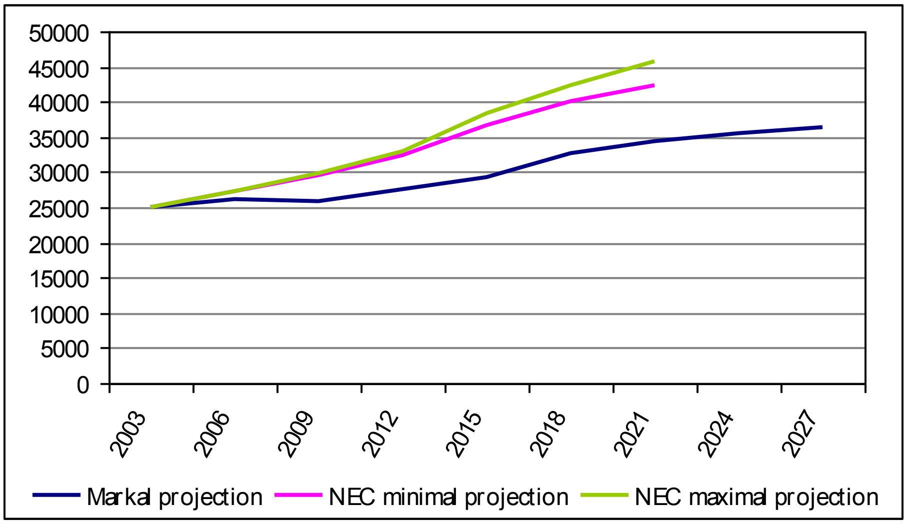
C.2.4.2 ELECTRICITY GENERATION REQUIREMENTS

Figure C-24 depicts Forecast of Electricity Demand according to MARKAL and the National Electricity Company (NEC) Projection Plan (GWh).

The actual values for 2003 for final electricity consumption are used and the projections start from a common value of 25 104 GWh. Unfortunately, data are not available for the period after 2021 and the projection from the NEC end at that date.

The difference between the MARKAL projection and the National Electricity Company (NEC) is due to the fact that the NEC is a trading company and its main goal is to increase its trade and revenues each year; thus additional exports of electricity are planned.

Figure C-24: Forecast of Electricity Demand



The Reference scenario reflects the expected growth in electricity generation owing to the construction of new nuclear plants. Electricity generation in the country is expected to fluctuate between 2009-2018 as two old nuclear plants are closed in 2009 and two new nuclear plants, one gigawatts each, are constructed with the expected online dates of 2015 and 2018, respectively. Coal power plants will generate the needed electricity when old nuclear plants are shutdown and will start tapering off when new nuclear plants become available and operational. Also, a new lignite power plant is planned, with in-service date of 2020.

It should be noted that the scenario does not take into consideration the barriers of high investment cost and the lead time for constructing nuclear plants and investing and building the needed transmission and distribution infrastructure to deliver the electricity to load center. The Reference scenario aims to capture the likely events that will take place over the planning horizon based on forecasted electricity needs. The model projection, including the forecast carried out in the National Energy Strategy, is shown in the Figure C-19 above.

Figures C-25 and C-26 show the evolution of power generation over time for the Reference scenario. Total electricity generation increases from 135 PJ to 183 PJ by 2027, a 35% rise, with

- 55% coming from nuclear;
- 28% coal-fired, forced down from a 38% share in 2003 owing to the increased role of nuclear;
- an increasing contribution from non-hydro renewables (biomass, geothermal and a small amount of wind); and
- hydro and gas remaining at about their 2003 levels.

As noted above, the up and down profile of generation reflects the retirement of nuclear plants, and the jumps resulting from the additional nuclear capacity planned for 2015 and 2018. [Note that imports and exports are capped at 2003 levels.]

Figure C-25: Electricity Generation by Fuel

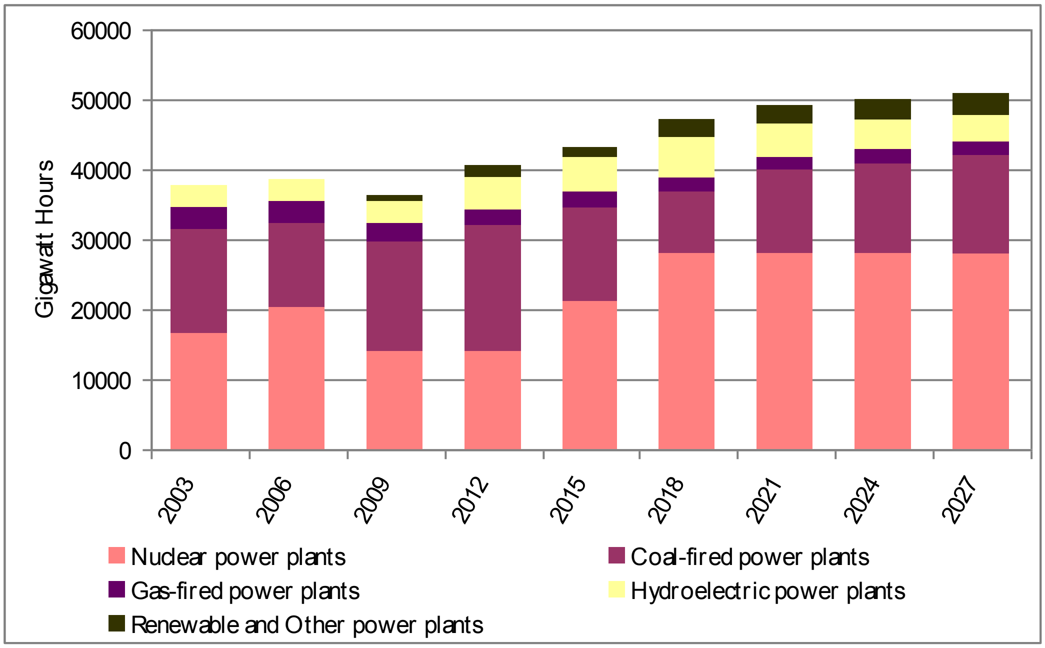
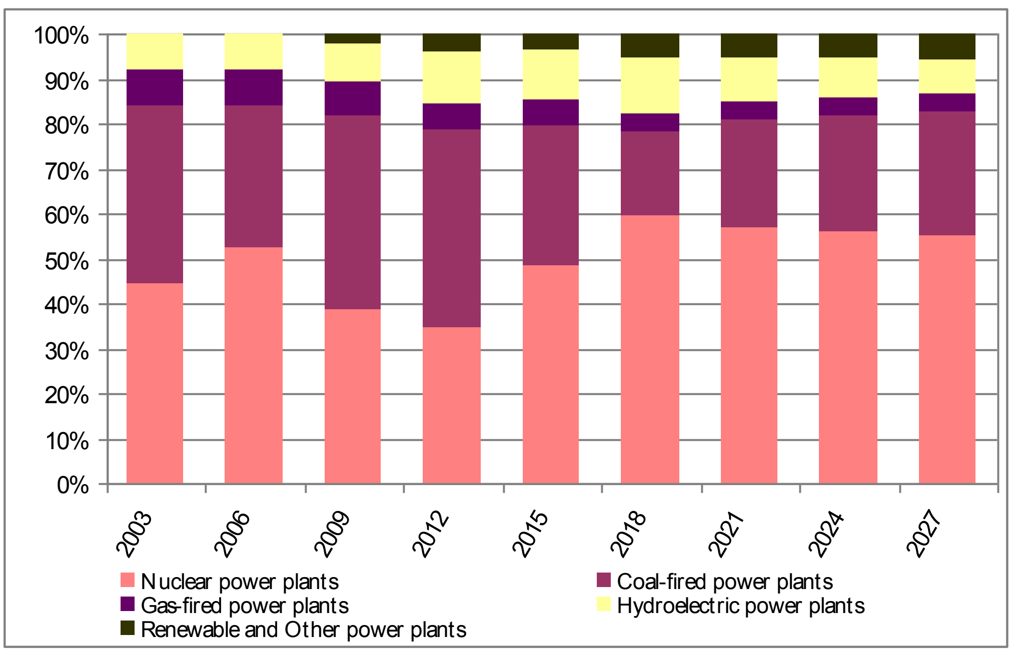


Figure C-26: Share of the Electricity Generation by Fuel



C.2.4.3 ENERGY SUPPLY

The supply of energy, from domestic sources and imports, for the Reference scenario is shown in Figures C-27 and C-28. The primary energy supply increases slightly over the planning period with the exception of 2009, when the nuclear units are shutdown. The supplies of coal and nuclear energy are highly dependent on each other. When nuclear power production decreases, the baseload coal power plants increase production.

Primary energy use in the country increases by 17% by 2027, with

- nuclear providing the bulk of the additional energy requirements, increasing from 38% to 43%;
- coal dropping from 31% down to 25%;
- biomass supply doubling;
- natural gas holding pretty much steady; and
- oil consumption (outside of the transportation sector) dropping by 50%.

Figure C-27: Energy Supply by Type

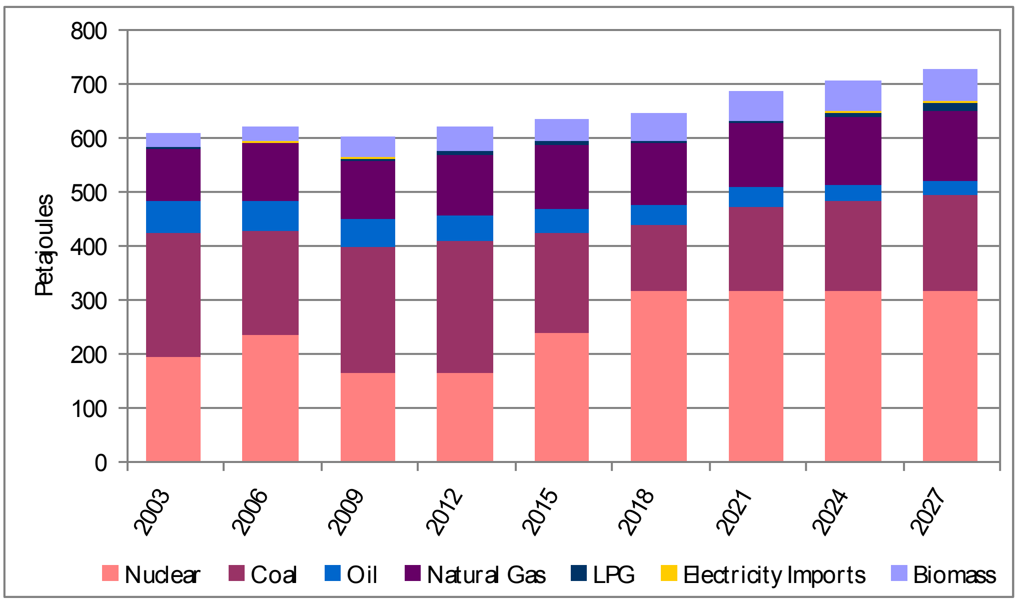
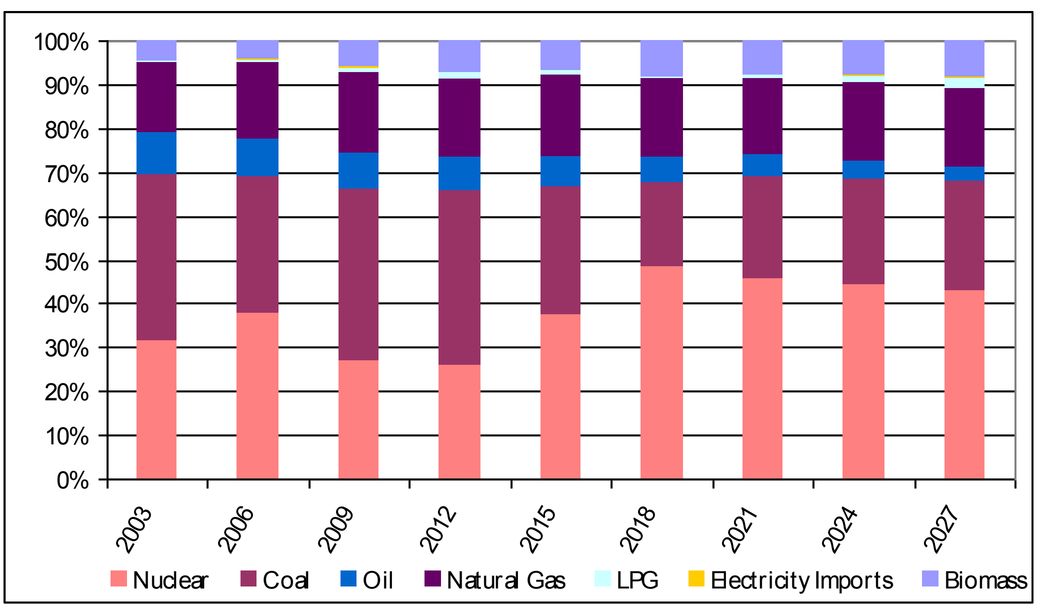


Figure C-28: Energy Supply by Type (Shares)



C.2.4.4 COSTS

Over the course of the planning horizon there is a constant trade-off between investments in the power sector and demand devices and expenditure on fuel. This trade-off usually takes the form of spending more to purchase more efficient demand technologies versus making large investments in the power sector and spending more on fuels. In the Reference scenario

- Fuel expenditures increase slightly during the planning horizon following the trend in production;
- Annualized power plant investments increase due to the fact that two nuclear power plants, one GW each, are planned to be constructed in years 2015 and 2018; and
- Annualized investments in power plants and demand devices reach €1.588 billion in 2021 and €1.73 billion in 2027, with investment in efficient demand devices increasing 4 times over the planning horizon.

C.3 SCENARIO ANALYSIS HIGHLIGHTS

Providing increased access to energy efficient demand technologies, and further promoting their uptake by means of policies aimed at reducing electricity consumption or improving energy intensity (total consumption / GDP) results in various changes to the evolution of the energy system. The information below thus reflects results of the R90/R90E/R90P scenarios, respectively. In general, the three scenarios represent progressively more demanding changes in the energy system, as their relative results illustrate.

- Primary energy use in the country decrease by 5/8/13% by 2027, with a corresponding improvement in energy intensity, where the main fuel shift is a reduction in coal consumption, particularly in the R90P scenario.
- Imports drop by 5.8/6.9/7.6% by 2027, improving energy security.
- Owing to the substantial availability of nuclear power, improved demand devices only result in a 4% reduction in the demand for electricity on their own. This increases t to a 10% reduction when improvement in overall energy intensity is imposed on the system.
  - Two major nuclear power plants come online when available in 2015 and 2018.
  - Less coal retrofit is called for in the R90E/P scenarios when further energy efficiency is encouraged.
  - Some biomass fueled power plants built in the Reference scenario are not required in the later periods.
- The R90 scenario results in an overall savings of €391 million over the 27-year modeling horizon, and €183 million in the R90E scenario.
  - Fuel expenditure decreases by €240/217/291 million per year by 2027, or 12.1/10.9/14.7% below the Reference.
  - Annualized investments in power plants drop only slightly in the R90/R90E scenarios, but increase by 11.5% (€56 million annually in 2027) as the system moves to more efficient power plants under the pressure to improve overall energy intensity.
  - At the same time, annual investments for new demand devices need to rise by 10.6/12.9/16.7%, (€132-203 million annually in 2027).

So the analysis conducted here serves to illustrate the merits of promoting increased energy efficiency through policies and programs aimed at improving the overall performance of the energy system.

C.3.1 FINAL ENERGY CONSUMPTION PATTERNS

Final energy consumption decreases as was the case for energy supply. The main reason for this drop is the fact that more energy efficient technologies are made available to replace the inefficient technologies. The Residential sector is the most dominant beneficiary of utilizing more energy efficient technologies, as shown in Figure C-29. Final energy consumption for the Residential sector drops dramatically between the Reference scenario and other scenarios but more importantly with the R90P scenario, Enhanced Energy Efficiency.

Figure C-29: Final Energy Consumption by Fuel

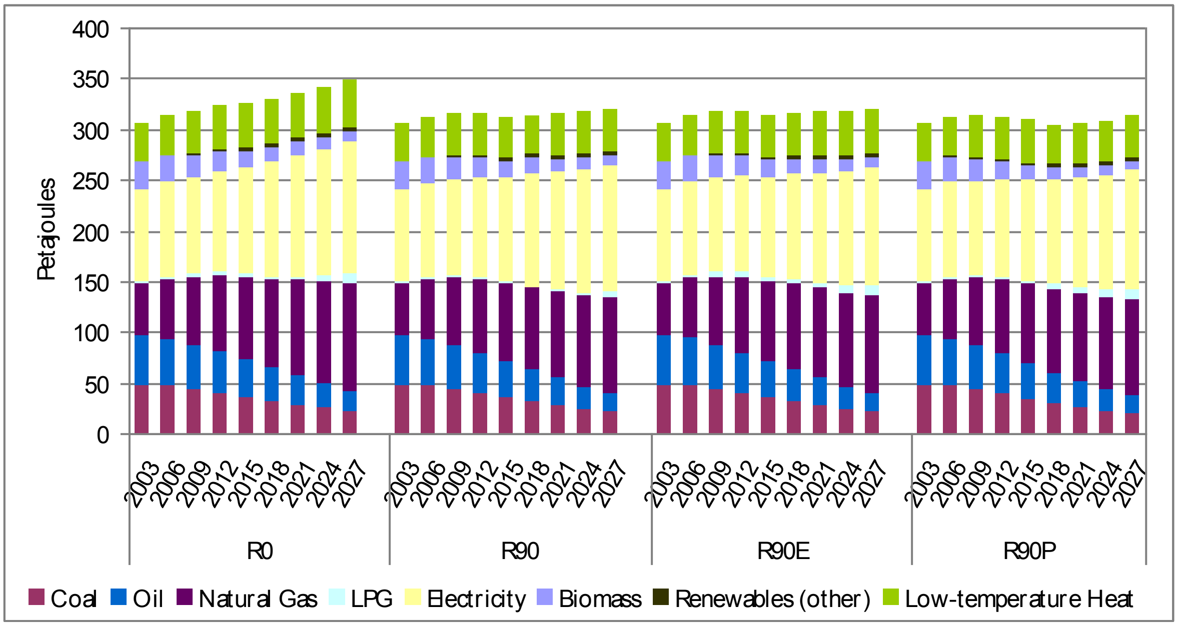
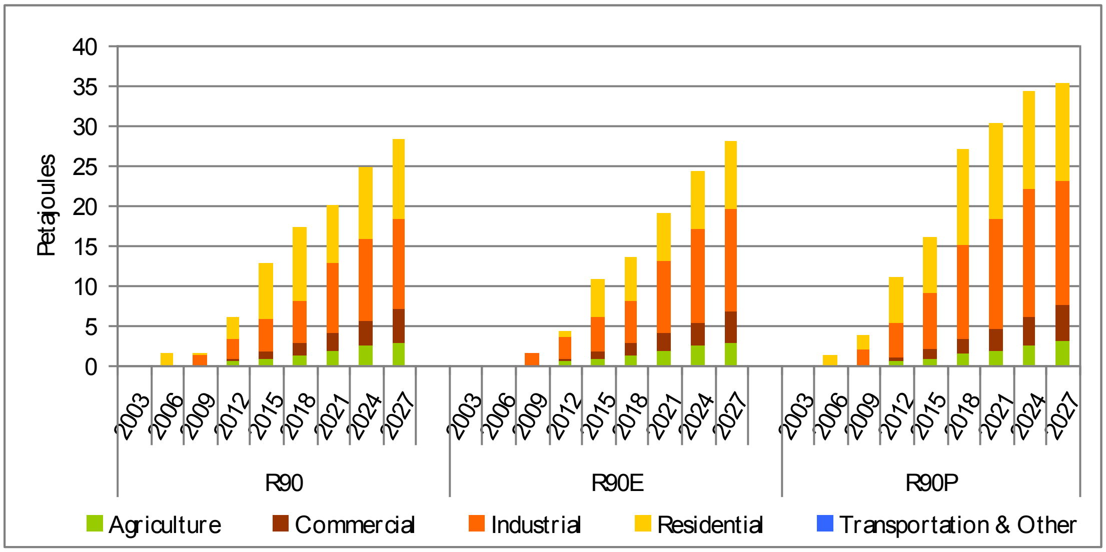


Figure C-30 depicts the savings in Final Energy Consumption by Sector. As noted above, the Residential sector is the major player in utilizing more energy efficient demand devices, thus reducing energy consumption in the out years. The Industrial sector is the second major player in reducing energy consumption by investing in more energy efficient demand devices. This shift in reduced energy consumption could only happen if strong national energy conservation programs are in place that provide enough incentives.

Figure C-30: Savings in Final Energy by Sector



C.3.2 POWER SECTOR INVESTMENTS AND ELECTRICITY GENERATION

As has already been discussed, the Bulgarian power sector is dominated by generation of electricity from nuclear plants, trading off against lignite fired plants. As can be seen in Figure C-31 this situation is most obvious in the 2009-2012 period where the coal must step-in to offset the loss of nuclear generating capacity, then reversed in 2015 and 2018 as new nuclear plants come online. And owing to this base of nuclear power the Bulgaria energy system has a lot of inertia (or a lack of incentive) to take measures that impact electricity consumption. Thus, the introduction of energy efficient technologies only reduces electricity consumption by 4.4%, requiring the introduction of policy to achieve more substantial reductions. As shown in Figure C-31 these measures can more than double this savings, while keeping the cost of the energy system below the Reference level. But it must be noted that export markets are not factored into the model decision-making, where efficiency might be of more interest so as to increase the amount of electricity available for export.

Figure C-31: Electricity Generation by Fuel

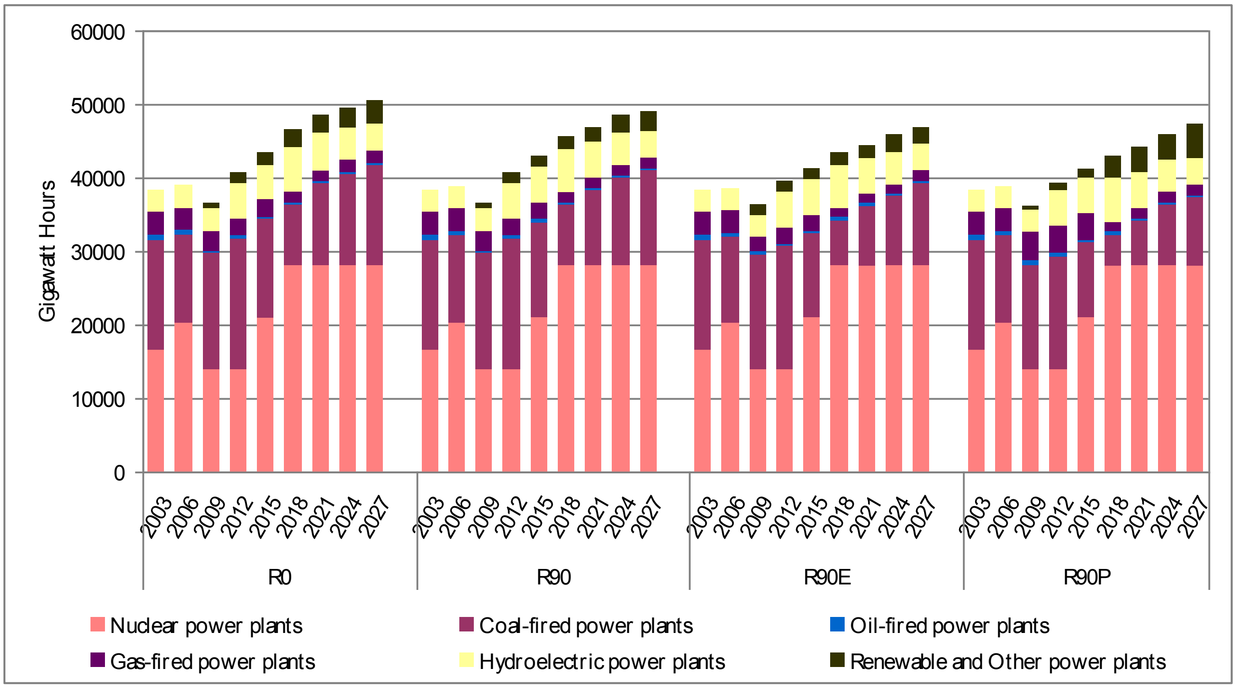
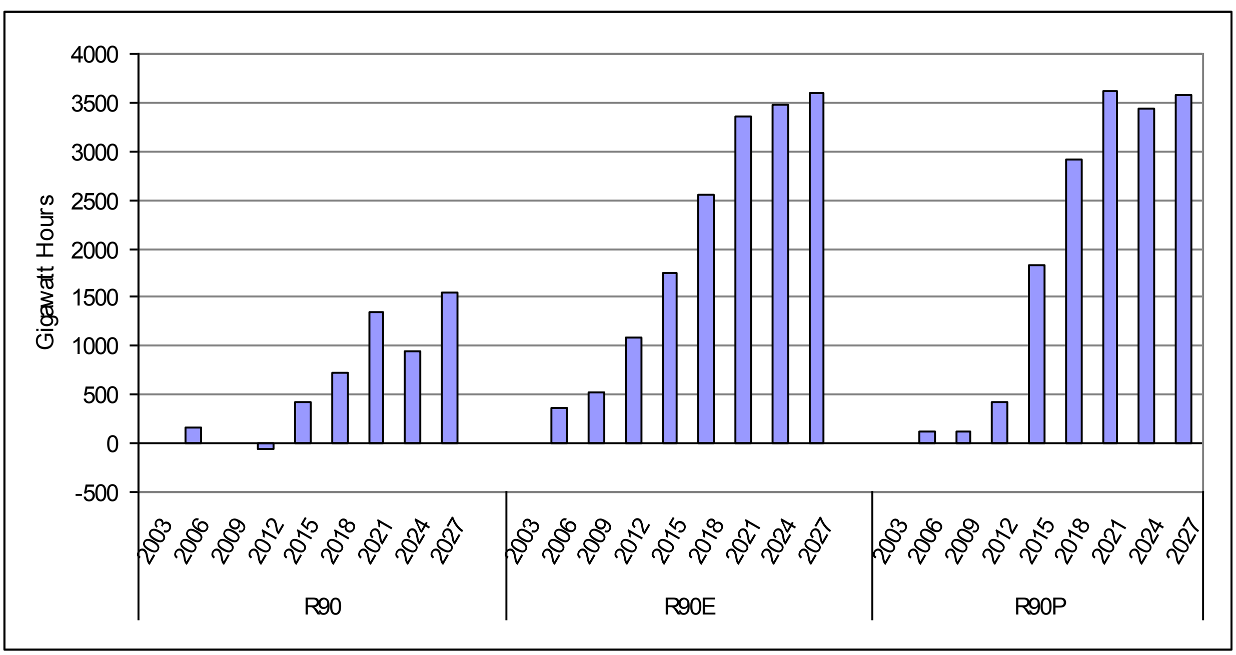


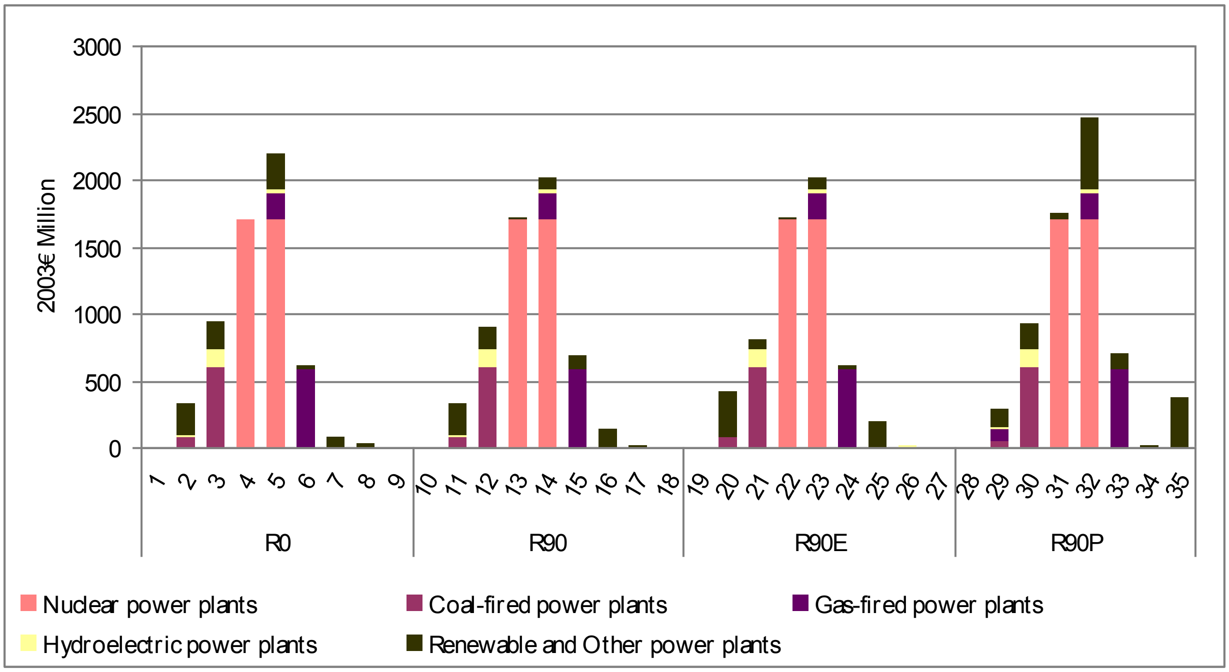
Figure C-32 below shows the Savings in Electricity Generation (GWh). The major electricity savings are seen in the R90E scenario – more then 7 % from the Reference scenario in 2027. Almost the same amount of savings is in place in the R90P scenario, which means that the improvement of the energy intensity of the system results mainly in electricity savings. It should also be noted that even in the "most liberal" R90 scenario the electricity savings in the last year are 1500 GWh, or almost 3 % in comparison with the same period in the Reference scenario.

Figure C-32: Savings in Electricity Generation



In terms of the foreseen timing for the investment in new, or refurbishment of existing, power plants, as shown in Figure C-33 the new nuclear plants dominate the power sector landscape. Even when unavailable they impact the energy system by forcing the need to build a 600MW lignite power plant and retrofit another 300MW, or increase imports.

Figure C-33: Investments in New (and Refurbished) Power Plants

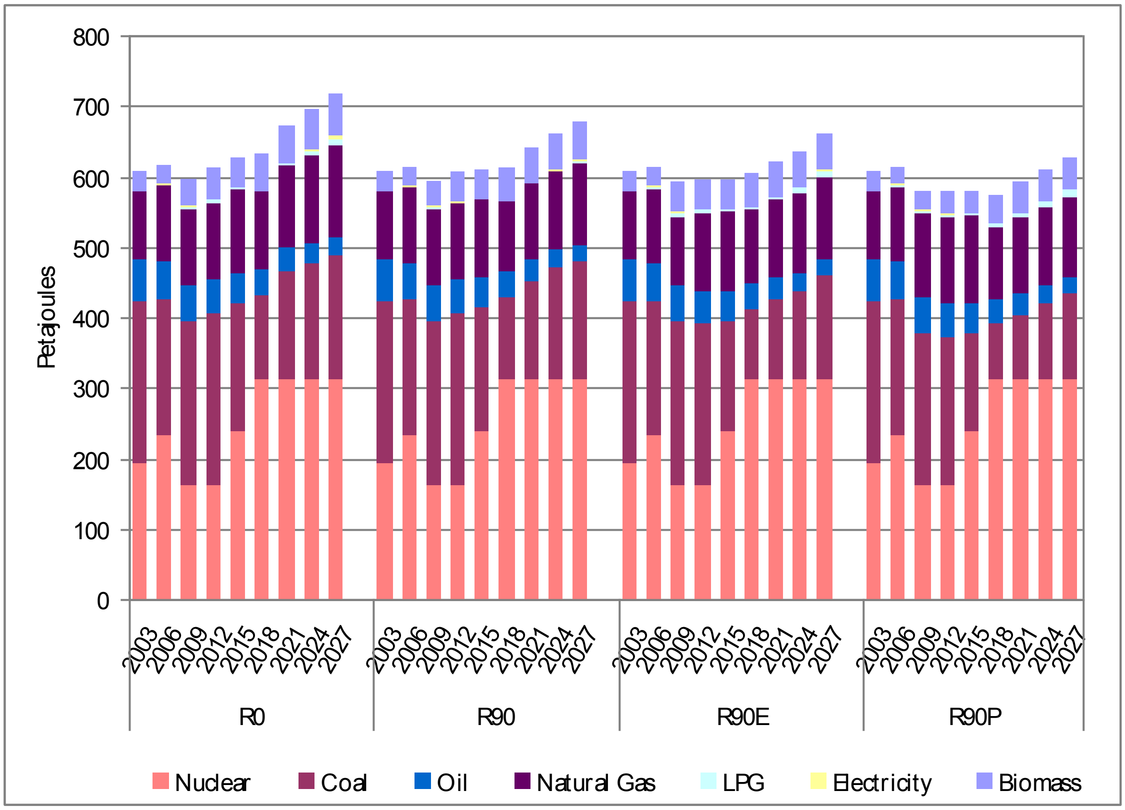


C.3.3 ENERGY SUPPLY PICTURE

The place to start understanding of the impacts of the various alternative scenarios is to examine the change in the supply of energy to the country. As can be seen in Figure C-34 there is a direct correlation between the additional nuclear capacity and the need for coal. There is also a tendency to reduce oil and biomass as the system seeks to become more and more efficient. One can also observe an overall drop in total energy consumed, the savings increasing as sterner policies are put in place at an incrementally higher cost for the energy system, as discussed in section C.3.4.

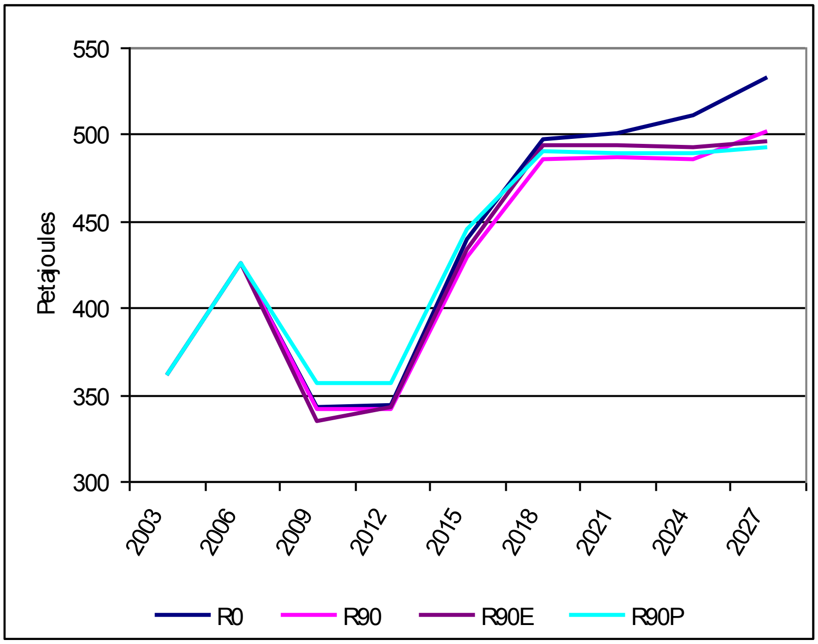
Note the pressure on the energy system in 2009-2012, where there is a noticeable shift in the nuclear/coal trade-off pattern. The "bump" in coal consumption is due to the closing of a nuclear plant, thus resulting in a need for increased electricity generation from coal (lignite) during that period.

Figure C-34: Supply of Energy



Owing to the dependency on imports for nuclear fuel, and the decreasing availability of domestic energy sources, Bulgaria becomes increasingly dependent upon imports. Despite the desire to maximize the benefits arising from the nuclear plants, and a 20-30% increase in the consumption of natural gas, policies introduced to curtail energy consumption reduce the share of imports by 10% towards the end of planning horizon as the energy system becomes more efficient. Note that the substantial drop in imports during the 2009-2012 period is due to the closing of the nuclear reactor and thereby no need for nuclear fuel to be imported.

Figure C-35: Total Imports



An important measure of the competitiveness of an economy is its overall energy intensity, or the amount of energy delivered (consumed) per unit of GDP. The table below shows the improvement in the energy intensity of the Bulgarian energy system for the three policy scenarios. In the case of the R90 and R90E scenarios the overall cost of the energy system also falls. The R90P shows that a 12.64% improvement can be achieved with the overall cost of the energy system not exceeding that of the less efficient Reference scenario but promoting energy efficiency and setting a policy to lower total consumption of energy.

Table C-4: Percentage Change from R0

2027 percentage change from R0

R90	5.38%
R90E	7.88%
R90P	12.64%

C.3.4 COSTS

Figure C-36 depicts the total discounted system cost of all four scenarios. System costs reflect closely the degree of the intensity of energy efficiency and conservation programs introduced through the policy scenarios. The R90 scenario which allows increased access to more energy efficient technologies is the least cost scenario over the planning horizon. The total discounted system cost drops by 1.2% from the Reference scenario. When the 10% energy conservation policy is introduced, scenario R90E, the total discounted system cost still shows improvement as compared to the Reference scenario but not as much as R90 scenario. The policy goal of Improve Energy Intensity, Scenario R90P, results in nearly the same total discounted system cost as the Reference scenario, but with an 8% improvement in the country's energy intensity.

Figure C-36: Total Discounted Energy System Cost

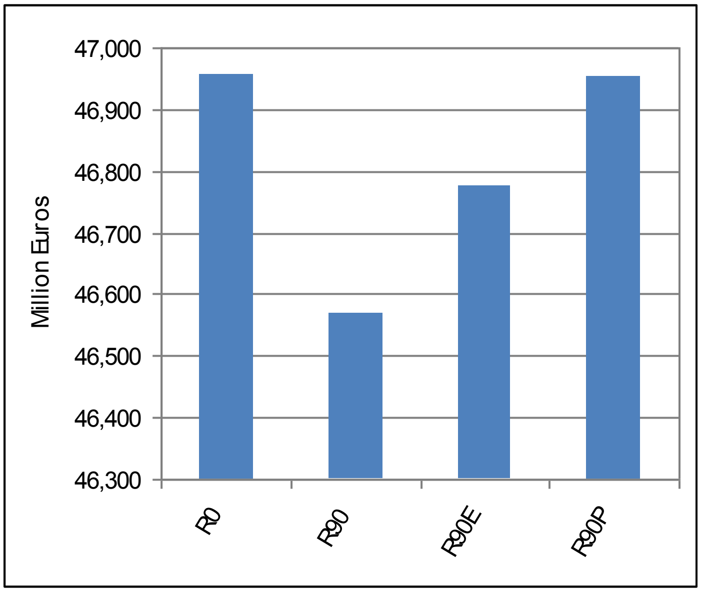
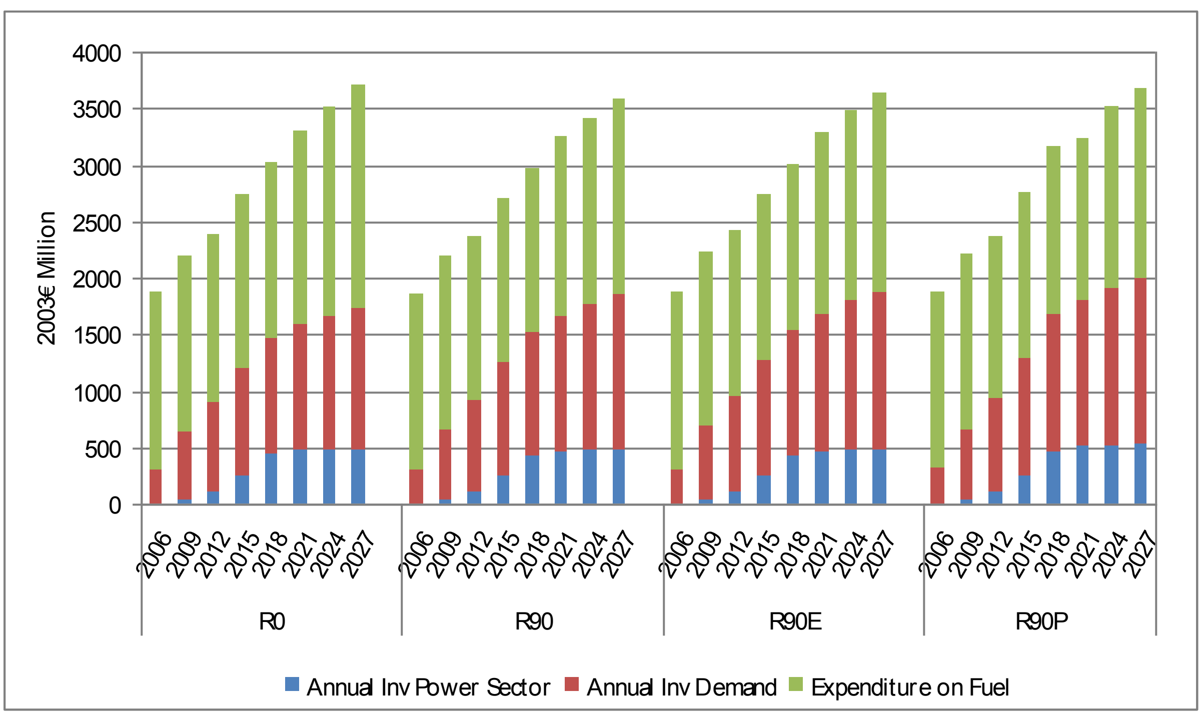


Figure C-37 depicts the scenarios' Annual Energy System Expenditures. The total expenditures for all four scenarios are the same but re-distributed from fuel expenditures to more investments in demand devices. This is expected since the policy scenarios' goals were to reduce fuel consumptions and increase energy efficiency through the introduction of more advanced and efficient demand technologies. This result can also be interpreted as growth in the economic activities (i.e., doing more for less) at the expense of fuel savings for the increased investment in demand technologies.

Figure C-37: Annual Energy System Expenditures



C.4 COUNTRY SPECIFIC ANALYSIS HIGHLIGHTS

According to the European requirements – Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market – Bulgaria as a member state has an obligation to establish a target for renewable energy-based electricity generation. Bulgaria adopted a target of 11 % share of gross domestic energy consumption till 2010.

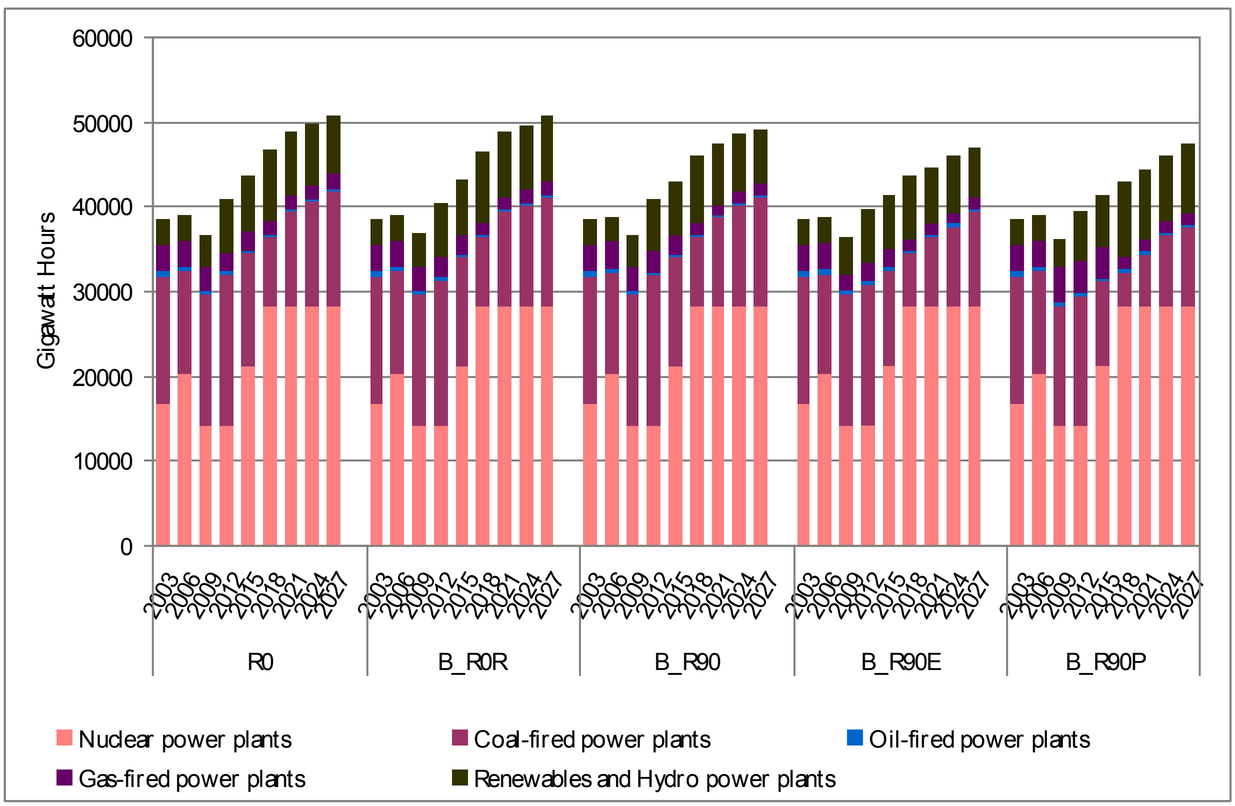
In this regard Bulgarian TWG members have made an additional scenario called R0R – fixed 11 % share of electricity generation from renewables from the gross domestic energy consumption from 2009 till 2027.

In order easily to account for the total share of the renewable energy sources renewable sources are combined with hydro power plants.

C.4.1 ELECTRICITY GENERATION

As shown in Figure C-38 the electricity generation in R0R scenario is not much different then in the Reference scenario. The most important here is the share of the renewables for the Reference and the R0R scenarios.

Figure C-38: Electricity Generation by Fuels



In the Reference scenario the share of the renewable electricity is 10.6 % of the electricity generation. Over the 27-year horizon, the share of renewables increases to 13.2 %. The main renewable sources are hydro, biomass and geothermal. Wind occupies a very small share.

Figure C-39: R0 2009 Electricity Generation by Fuels

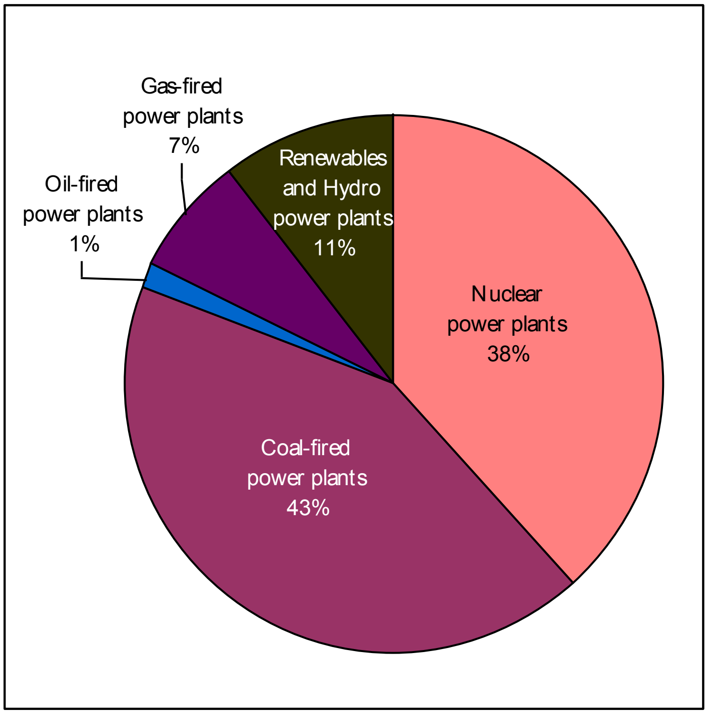
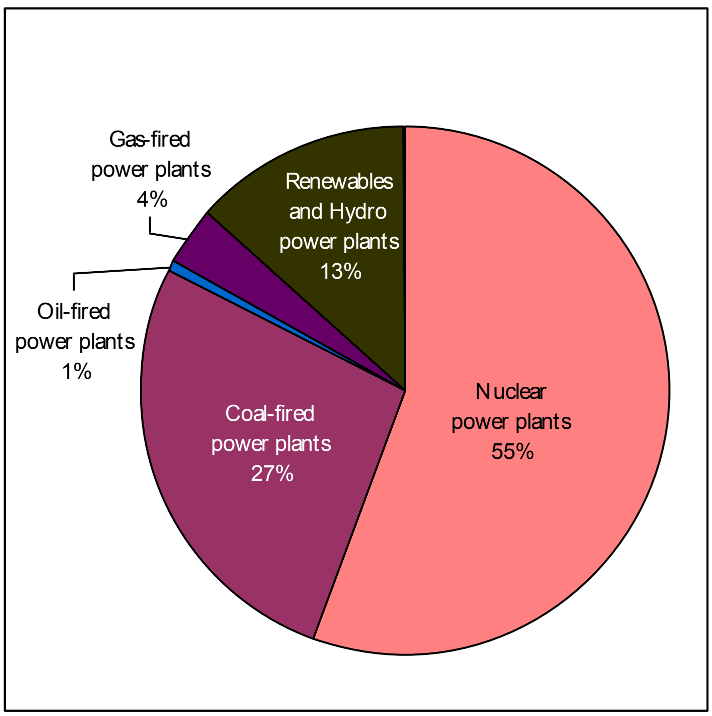


Figure C-40: R0 2027 Electricity Generation by Fuels



When comparing the R0 and R0R scenarios, the increase in renewables is apparent, particularly in the last year when the share reaches 15.4 %. The main source is hydro energy followed by biomass and geothermal energy. Wind electricity is growing very fast especially in the last years. Solar production absent, owing to the high costs.

Figure C-41: R0R 2009 Electricity Generation by Fuels

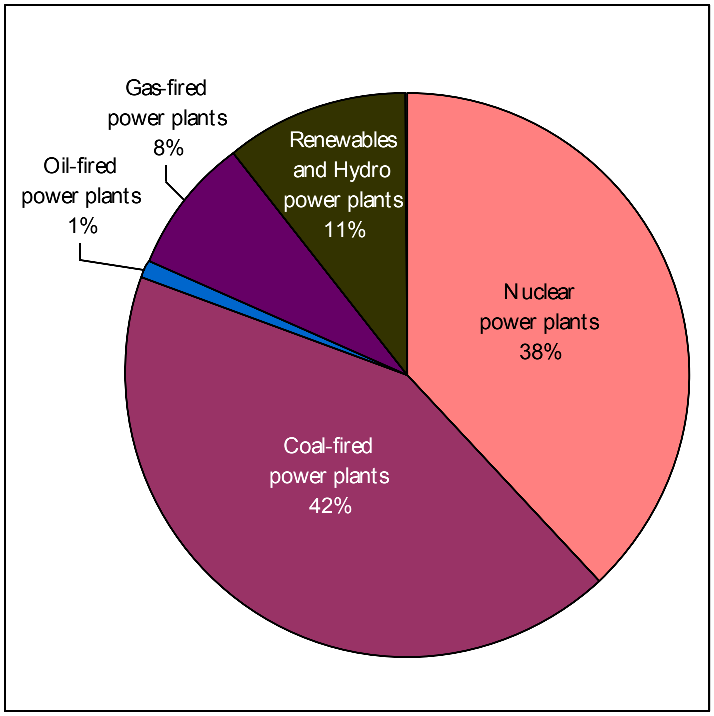
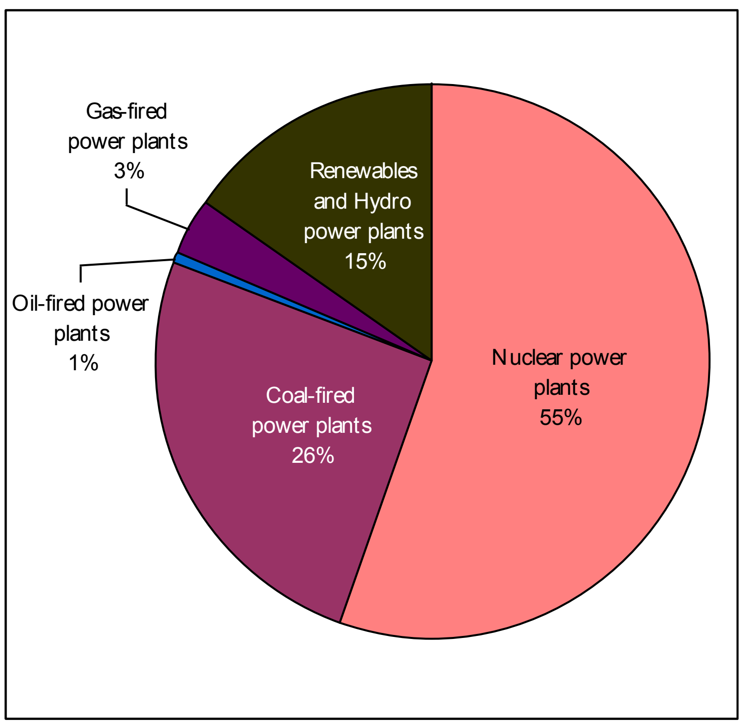


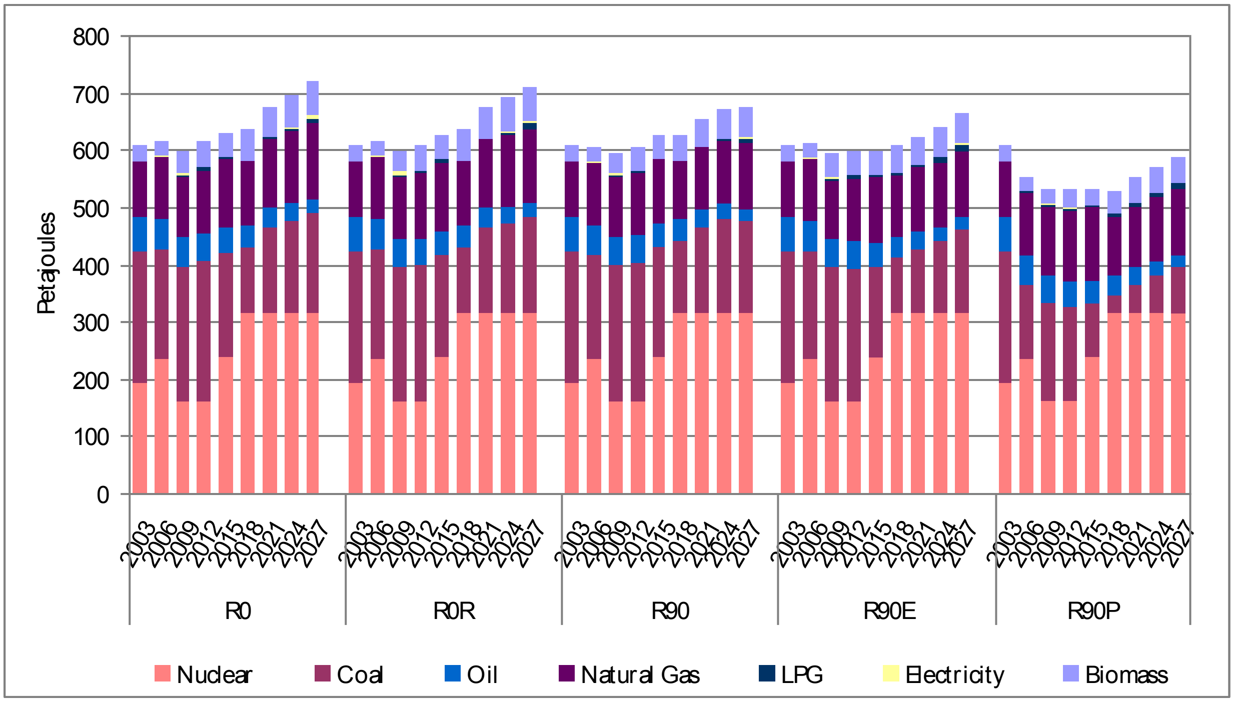
Figure C-42: R0R 2027 Electricity Generation by Fuels



C.4.2 ENERGY SUPPLY

Figure C-43 shows energy supply in all 5 scenarios. In the R0R scenario a decrease in the energy supply results largely from the increase of the renewables share in energy consumption and the replacement of other mined or imported sources which are included in the total primary energy supply. As a whole, the R0R scenario is more energy intensive in comparison with all other sensitivity runs. This is because of the starting point used there –access to more efficient technologies is still limited to 10 %.

Figure C-43: Primary Energy Supply



C.4.3 CARBON DIOXIDE EMISSIONS

Figure C-44 shows how the different measures contribute to reduction of carbon emissions. The big reduction in 2015 and 2018 is a result of the replacement of lignite power plant units with the new nuclear units. After 2020 a new lignite unit is expected so the emissions increase again.

The increased share of renewable energy sources in R0R, results in a small reduction in CO_2 emissions. The R90 scenario with increased access to improved demand technologies shows better results. The energy efficiency scenarios – R90E and R90P –achieve the biggest contribution to the climate change mitigation – around 30 % in comparison with the 2003 values.

The main conclusion to be made is that the best way to reduce greenhouse gasses is by improving energy intensity, especially when this does not require an increase in system costs.

Figure C-44: CO_2 Emissions